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MORPHOLOGICAL AND ECOLOGICAL DIFFERENTIATION OF *PEROMYSCUS MERRIAMI* FROM SOUTHERN ARIZONA

BY LARRY R. COMMISSARIS

The taxonomic status of the desert mouse, *Peromyscus merriami*, has long been in question. Mearns (1907) first named the species from eleven specimens taken at Sonoyta, Sonora, Mexico during the border survey of 1892–1894. Osgood (1909), in his revision of the genus, placed *merrriami* as a synonym of *Peromyscus eremicus*. Hall and Kelson (1952) have subsequently examined the original specimens and have concluded that *P. merriami* is, indeed, distinct from *P. eremicus*.

Although the two forms now stand as separate species, there is little information concerning their distinguishing characteristics. Mearns (*op. cit.*) has stated that *P. merriami* is larger and stouter than *P. eremicus*, with a skull that is also larger and heavier. Osgood (*op. cit.*), however, stated, "The so-called *P. merriami* is, indeed, larger than typical *eremicus*, but only slightly larger, and not in the least different otherwise." It is the purpose of this study to help clarify the taxonomic status of these two forms by (1) presenting evidence of reproductive isolation and (2) comparing populations of the two forms to show morphological and ecological differences between them.

METHODS

Peromyscus merriami is reputed to be a lowland dweller occurring in mesquite communities and fields while *P. eremicus* is abundant in rocky areas (Mearns, 1907; Dice and Blossom, 1937). With this habitat difference in mind, a study area was chosen where these two habitats occur adjacent to each other and present a well-defined ecotone. This area, located 9 miles south of Tucson, Pima County, Arizona, includes Sahuarita Butte, a rocky lava hill which rises 325 feet above the valley floor, and a large mesquite forest along the south and west sides of the butte. The dominant vegetation on the butte is palo-verde (*Cercidium microphyllum*) and saguaro (*Cereus giganteus*), while mesquite (*Prosopis juliflora*) dominates almost exclusively in the mesquite forest below. These two are, respectively, the "Rock Hill Association" and the "Mesquite Forest Association" of Dice and Blossom (*op. cit.*).

Trapping was carried out during the winter of 1956–57. Forty-five specimens, 23 from the mesquite area and 22 from Sahuarita Butte, were employed

in the study. All trapping was carried out at a distance of 300 feet or more from the ecotone area in order to minimize the chance of trapping wandering individuals from the adjacent habitat. Specimens were also collected in the ecotone for comparative purposes, but this material was not used in any of the computations.

Skull measurements (Table 1) are those defined by Cockrum (1955). Specimens used in this study are now deposited in the mammal collection of the Department of Zoology of the University of Arizona.

RESULTS AND DISCUSSION

Slight external differences were noticed between freshly captured specimens collected in each habitat. Specimens trapped in the mesquite area usually were larger, and a cinnamon pectoral area was often present. This pectoral spot was quite variable, however, with some specimens having large spots and others having none. Occasionally the cinnamon pectoral spot appeared in specimens from the butte. Mearns (*op. cit.*) has pointed out that "The two have the same coloration, except that *P. merriami* is somewhat darker, has the light cinnamon color extending down the outer side of the forelimb to the hand, and a large pectoral patch of cinnamon that is usually wanting in *P. eremicus*." With the exception of the pectoral area, the differences in coloration were slight, however, and often disappeared or were obscured when the animal was prepared as a study skin.

In comparing the measurements of specimens from the two populations (Table 1), the males and females from each were first compared using the *t*-test to determine if any sexual dimorphism existed within each population.

TABLE 1.—*A comparison of 22 specimens of Peromyscus eremicus pullus from Sahuarita Butte with 23 specimens of Peromyscus merriami from the adjacent mesquite forest; measurements in millimeters*

MEASUREMENT	*Peromyscus eremicus* Mean with Standard error	*Peromyscus merriami* Mean with Standard error	*t*	*P*<
Total length	181.4 ± 2.04	193.0 ± 2.66	3.46	.01
Tail length	96.9 ± 1.53	100.3 ± 1.78	1.45	.20
Body length	84.5 ± 1.18	92.2 ± 1.49	4.05	.001
Hind foot length	19.9 ± 0.16	22.2 ± 0.18	9.54	.001
Height of ear from notch	19.0 ± 0.29	21.6 ± 0.19	7.50	.001
Greatest length of skull	24.75 ± 0.15	25.66 ± 0.17	4.03	.001
Basilar length	18.82 ± 0.16	19.66 ± 0.18	3.49	.01
Greatest breadth braincase	11.51 ± 0.06	11.75 ± 0.07	2.61	.02
Interorbital constriction	3.97 ± 0.03	3.76 ± 0.03	4.96	.001
Length of nasals	8.81 ± 0.09	9.04 ± 0.10	1.71	.10
Length of palatal bridge	3.84 ± 0.05	4.09 ± 0.05	3.54	.01
Length of incisive foramina	4.83 ± 0.06	5.18 ± 0.04	4.86	.001
Length of diastema	6.16 ± 0.04	6.34 ± 0.07	2.23	.05
Postpalatal length	9.14 ± 0.09	9.37 ± 0.10	1.71	.10
Length maxillary toothrow	3.74 ± 0.03	3.96 ± 0.04	4.42	.001
Mastoid breadth	10.96 ± 0.06	11.75 ± 0.07	8.46	.001

No significant ($P = .05$) sexual dimorphism was found in either population; this agrees with Hall's (1946) findings for *P. eremicus* in southern Nevada.

The 16 measurements in Table 1 show a large amount of difference between the two populations. Except for interorbital constriction, the mesquite forest population is larger in every respect. The mastoid breadth, hind foot, and ear measurements, especially, show large differences. This number of highly significant morphological differences between two populations in ecological proximity implies that the two populations have little, if any, direct gene exchange.

It soon became evident that specimens from the two populations could be visually separated by viewing the dorsal side of the cleaned skull. Almost invariably the mastoid process could be seen projecting beyond the braincase in members of the mesquite forest population, but not in the Sahuarita Butte population (Fig. 1). The mastoid breadth measurement was incorporated into the study to quantify this visual difference. It proved to be a reliable measurement, and it was possible to separate the two forms by using it. The Sahuarita Butte form measured less than 11.4 mm. while the mesquite form was more than this. The mean values were significantly different at the .001 level (Table 1).

A series of specimens taken from the ecotone between the two communities showed no intermediate forms, nor was there any evidence of permanent dispersal of one form into both communities. Individuals in this series could each be referred to one population or the other on the basis of the characteristics cited in Table 1. Since gene dispersal in *Peromyscus* is accomplished to some extent by dispersal of young individuals (Blair, 1953), it would be ex-

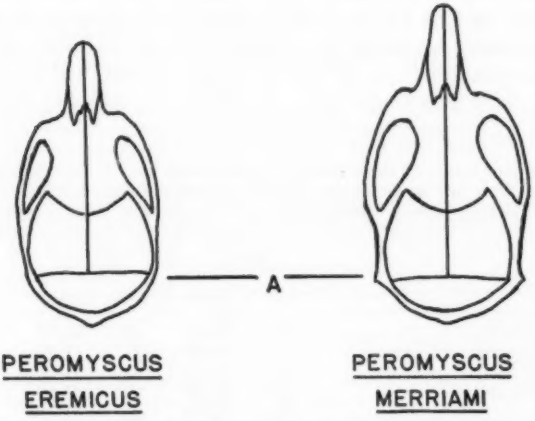

FIG. 1.—A dorsal view of the skulls of representative individuals of the two species in the study, which shows the projecting mastoid process (A) that is characteristic of *Peromyscus merriami*.

pected that mice referable to one population would be found in the area occupied by the adjacent population, especially near the ecotone area. Trapping along the ecotone has shown that permanent dispersal into the adjacent habitat does not occur. Specimens with characteristics of the butte population have not been taken in the mesquite growth, nor were specimens referable to the mesquite forest population ever taken in the palo-verde on the butte. Thus, there is apparently no permanent dispersal from one habitat into the other, suggesting specific habitat requirements.

The coefficient of divergence for use with multiple characters (Clark, 1952) makes it possible to compare the two populations from the study area with each other as well as with related forms known to occur in the southern part of Arizona. Three cranial measurements (Table 2) were used in calculating the coefficients. These measurements, which have only slight individual variation, can be used to show geographic and subspecific variation (Hoffmeister, 1952).

Figure 2 shows the results of comparison of several populations of the two related groups. The subspecies within the species *Peromyscus eremicus* diverge only a small amount. The exceedingly slight divergence shown between *P. e. pullus* and the population on Sahuarita Butte, 3 miles from the type locality of *pullus*, indicates that the butte population is nothing more than a slightly variant population of the subspecies *pullus*.

In contrast, the mesquite bosque population diverges considerably from the subspecies of *Peromyscus eremicus*. It does not, however, diverge greatly from *Peromyscus merriami* from the type locality. This latter divergence falls within the range of subspecific divergence in *P. eremicus*. The data suggest that the mesquite bosque population is *Peromyscus merriami* and that it differs from the type series of *merriami*, at most, only at the subspecific level.

Mearns (*op. cit.*), in his key to the species of *Peromyscus* found along the Mexican boundary, separated *P. merriami* from *P. eremicus* on the basis of several characteristics: (1) hind foot more than 22 mm., (2) skull length more than 26 mm., (3) total length more than 210 mm., and (4) chest and wrists

TABLE 2.—*Mean values of three cranial measurements used in calculating coefficients of divergence presented in Fig. 2; specimens of P. e. anthonyi from Hachita, Grant Co., New Mexico and Alamos, Sonora, Mexico, and of P. e. eremicus from Yuma Co., Arizona*

POPULATION	GREATEST LENGTH		CRANIAL BREADTH		MAXILLARY TOOTHROW	
	No.	Mean	No.	Mean	No.	Mean
P. eremicus anthonyi	15	25.00	17	11.87	17	3.69
P. eremicus eremicus	17	24.98	17	11.45	17	3.88
*P. eremicus pullus**	19	24.74	21	11.51	22	3.74
P. eremicus pullus†	20	24.59	21	11.63	21	3.78
*P. merriami**	21	25.66	22	11.75	22	3.96
P. merriami†	5	25.70	5	11.85	5	4.02

* Specimens from the study area at Sahuarita Butte, Arizona.
† Specimens from the type locality of the species.

usually colored. Table 1 indicates that the length of the hind foot for the mesquite forest form exceeds his citerion, while the greatest skull length closely approaches it. The total length differs considerably from 210 mm., however, but the coloration, as previously described, follows fairly well. Since Mearns had but eleven specimens on which to base his description, it seems probable that his specimens did not represent the full spectrum of characteristics present in the species.

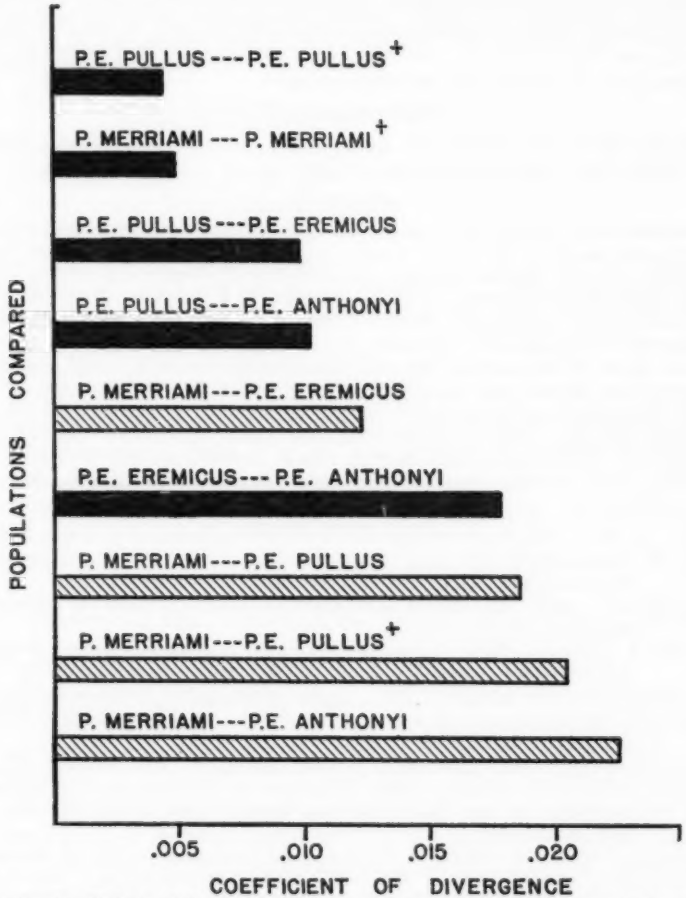

FIG. 2.—Coefficients of divergence comparing the species *Peromyscus merriami* and three subspecies of *Peromyscus eremicus* found in southern Arizona. Solid bars represent comparisons between populations of the same species, while diagonally striped bars show comparisons between different species. The + mark indicates the group is from the type locality. *P. merriami* and *P. e. pullus* are from the study area, unless otherwise noted, while *P. e. eremicus* and *P. e. anthonyi* are from the areas given in Table 2.

I have examined five adult specimens from the type series of *Peromyscus merriami* and have found that they show all the characteristics found in the mesquite forest form of the study area. The projection of the mastoid process beyond the braincase, when viewed dorsally in these specimens, was quite evident. Nor did mean values of the skull measurements differ greatly. As shown previously by the coefficient of divergence, the two populations did not differ more from each other than subspecies of *P. eremicus* differed within that species. Thus, it seems reasonable to conclude that *Peromyscus merriami* is a distinct species from *Peromyscus eremicus*, differing both in morphology and ecology, and that it is found inhabiting the mesquite infested lowlands of the southern part of Arizona and adjacent areas.

ACKNOWLEDGMENTS

Grateful thanks are extended to E. Lendell Cockrum, Charles Lowe, Richard Van Gelder and William G. George for their many helpful suggestions.

SUMMARY

The present paper reviews the taxonomic status of *Peromyscus merriami* and *Peromyscus eremicus* and presents information on morphological and ecological differences between the populations found in southern Arizona. The coefficient of divergence is used to compare several subspecies of *P. eremicus* and two populations of *P. merriami*. It was found that *P. merriami* showed considerable divergence from *P. eremicus*, which was interpreted as evidence of its distinctness as a species. The desert mouse was larger than the cactus mouse in almost all measurements that were taken, and the two species could be separated by viewing the cleaned skulls dorsally. In *P. merriami*, the mastoid processes projected beyond the sides of the braincase but this did not occur in *P. eremicus*. Besides this qualitative difference, there were numerous quantitative differences. The habitat requirements for the two species also differed, with *P. merriami* found in lowland areas of deep soil, and *P. eremicus* found in rocky areas. It is concluded that the two forms represent taxonomically sound species.

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A STUDY OF SOME LIPIDS IN TISSUES OF THE OPOSSUM

By Stanley J. Brumleve and X. J. Musacchia

Studies of tissue lipids have been made in a wide variety of mammals, both wild and domesticated. The marsupials have generally been overlooked. The absence of detailed knowledge of tissue lipids in these mammals is clearly evident in Bloor's monograph (1943), and the condition has not been changed in subsequent years. In order to study this subject, the opossum, *Didelphis marsupialis virginiana* Kerr, was selected for analyses of tissue total fatty acid, cholesterol and phospholipid.

MATERIALS AND METHODS

Adult specimens were collected within a 50-mile radius of St. Louis, Missouri. Five opossums (Group I) were killed several hours after capture and are herein referred to as "wild" subjects. Another five specimens (Group II) were captured and housed in animal rooms for three to four weeks, and are herein referred to as "captive" subjects. They were fed a diet of Purina Laboratory Chow, occasional leafy vegetables, and water *ad libitum*. The adequacy of laboratory feeding and maintenance may be judged in light of our success in the past. Opossums in these laboratories have reproduced, reared young and have been maintained in a healthy condition.

All specimens were killed by a sharp blow on the head. Pieces of tissue for lipid extraction were removed from freshly killed animals. The pieces were weighed, immersed in alchol-ether (3:1) and ground to a paste with fat-free sand. Blood and tissue lipids were extracted in hot alcohol-ether, a filtrate prepared and aliquots taken for the individual lipid analysis. The lipid methods used are described in the literature: cholesterol (Bloor, 1917), phospholipid (Bloor, 1929) and total fatty acids (Bloor, 1947).

Table 1.—*Amounts of lipids in tissues of the opossum. All values are in per cent of fresh tissue; means and standard error of the mean are given*

Tissue and no. determinations		Total fatty acids		Cholesterol		Phospholipid	
		Wild	Captive	Wild	Captive	Wild	Captive
Glandular:							
thyroid	5	5.78±.06	4.81±.13	0.46±.04	0.40±.04	6.02±.10	4.35±.06
adrenal	5	4.75±.13	4.99±.02	0.25±.03	0.66±.13	5.29±.06	4.31±.14
Muscle:							
cardiac	5	2.58±.02	1.97±.03	0.13±.00	0.12±.00	2.05±.02	2.47±.03
pectoralis	5	2.01±.02	1.94±.03	0.09±.01	0.06±.02	1.77±.03	1.65±.03
diaphragm	5	2.69±.06	2.37±.03	0.12±.02	0.09±.01	1.81±.04	1.24±.01
Vascular:							
liver	10	3.59±.02	3.89±.02	0.32±.05	0.29±.01	1.53±.02	1.12±.01
spleen	5	2.00±.02	1.95±.02	0.45±.04	0.36±.02	1.79±.02	1.72±.02
kidney	10	3.31±.02	3.21±.02	0.44±.03	0.37±.02	1.96±.04	1.24±.02
lung	5	2.37±.04	1.86±.02	0.52±.12	0.39±.06	1.52±.05	1.18±.02
blood	5	— —	848 ±.10	364 ±.14	118 ±.01	583 ±.19	534 ±.09

RESULTS

The values obtained represent levels of lipid concentration in various tissues of the opossum. They are summarized in Table 1. The total fatty acid concentrations are relatively similar in identical tissues of captive and wild specimens. The blood and glandular tissues have the highest phospholipid values.

There are, however, some marked differences in cholesterol and phospholipid levels. For example, the captive opossums have about 60 per cent less blood cholesterol, and the glandular tissue, thyroid and adrenal, from captive specimens has conspicuously less phospholipid.

According to the ratio, phospholipid/cholesterol, the tissues show two distinct groupings (Table 2). The muscle tissue values were uniformly elevated and the highly vascular tissues were consistently low. The glandular tissues in wild opossums have a low total fatty acid/phospholipid relationship.

DISCUSSION

Some of the data suggest that captivity may influence the lipid composition of a few tissues. In this regard, the notably lower phospholipid concentration of the thyroid and adrenal of captive specimens is cited. An examination of the total fatty acid/phospholipid ratio (Table 2) further amplifies the difference in the adrenal of wild and captive opossums. The cholesterol content of the adrenal is approximately doubled in the captive animals and in the relationship phospholipid/cholesterol, there is a threefold difference (Table 2). Long (1947) and Conn *et al.* (1950) consider that under conditions of stress or with increased cortical activity there is a reduction of adrenal cholesterol, and that the blood is the source of adrenal cholesterol. The results obtained, i.e., low adrenal and high blood cholesterol levels in wild opossums, suggest that in the wild these animals are under conditions of stress and/or the embarrassment of capture plus transportation to the laboratory prior to killing may also account for conditions of stress. These features in the lipid composition of the opossums' adrenals argue for increased biochemical research using the opossum as an experimental animal.

The differences in cholesterol content of the three muscle tissues studied (Table 1) are in accord with Bloor's (1943) contention that involuntary muscle rather than voluntary muscle has a higher cholesterol content. Wilber and Gorski (1951) used methods similar to those in the present investigation and also found this to be true of bison muscles.

Bloor has reviewed the subject of lipid relationships and holds the view that wide variations exist in the so-called "constant" factors of tissue lipids, i.e., phospholipid and cholesterol. In the present investigation, the phospholipid/cholesterol ratio was found to differ in cardiac and pectoralis (skeletal) muscle from wild and captive opossums (Table 2). This suggests that an alteration in muscle lipid composition may result from the physical restriction or the modified diet of the laboratory. The present results are therefore in accord with Bloor (1927, 1936) and Bloor and Snider (1934), wherein they showed that

TABLE 2.—*Ratios of lipids in tissues of the opossum*

TISSUE	TOTAL FATTY ACIDS ÷ PHOSPHOLIPID		PHOSPHOLIPID ÷ CHOLESTEROL	
	Wild	Captive	Wild	Captive
Glandular:				
thyroid	0.96	1.11	13.[illegible]3	10.87
adrenal	0.90	1.15	21.[illegible]6	6.53
Muscle:				
cardiac	1.26	0.80	15.77	20.58
pectoralis	1.14	1.12	19.66	27.58
diaphragm	1.49	1.91	15.08	13.77
Vascular:				
liver	2.35	3.47	4.[illegible]8	3.52
spleen	1.12	1.13	3.[illegible]7	4.77
kidney	1.68	2.59	4.[illegible]5	3.35
lung	1.56	1.57	2.[illegible]2	3.02
blood	—	1.62	1.33	4.52

muscles had no definite phospholipid and cholesterol content; they showed differences in content between voluntary, smooth and cardiac muscle and differences in identical muscles, depending on the extent of use.

Blood lipids in the opossum are comparable with those of the arctic ground squirrel (in mg. per 100 ml.): 833, 224 and 625, respectively, for total fatty acids, cholesterol and phospholipid (Musacchia and Wilber, 1952).

The chief worth of the lipid values presented is in their probable use in future investigations involving the opossum and in the fact that captivity does alter, to a limited extent, the lipid composition in tissues of this animal.

SUMMARY

The lipids in a variety of organs and tissues of wild and captive opossums were evaluated. The total fatty acid concentrations are relatively similar in identical tissues of both captive and wild opossums. The animals maintained in captivity have about 60 per cent less blood cholesterol, whereas the adrenals of the captive animals have approximately twice as much cholesterol. The concentration of phospholipid of the glandular tissues is markedly higher than that of other tissues. The ratio phospholipid/cholesterol shows that the tissues have two distinct groupings; the various muscles were uniformly high and the vascular tissues were consistently low. Captivity and its possible role in tissue lipid composition in opossums is discussed.

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TADARIDA YUCATANICA IN TAMAULIPAS

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The free-tailed or guano bat of Yucatan, *Tadarida yucatanica* (Miller), occurs on the Yucatan Peninsula, Mexico, with a marginal distribution southward to Belize or British Honduras (Murie, 1935: 19), El Salvador (Felten, 1957: 8) and Guatemala, according to Sanborn (1941: 387), but no farther north in Mexican territory.

It is therefore of interest to find a colony of this species among the multitude of rifts, channels and winding hollows among the stalactites formed in the walls of Cueva del Abra, 10 km. NNE Antiguo Morelos, in extreme southern Tamaulipas, a short distance from the Panamerican Highway on the east slope of the Sierra de la Cuchara. The opening of the cave faces south and, due to its large size, can easily be seen from the highway, built in the depths of the canyon or "Abra" of the range, to which it owes its name. It has been suggested that this may be one in a system of caves and subterranean galleries of great depth (Cueva de Quintero, Cueva del Pachón, and others) which occur in close proximity in this region. Nevertheless, in various expeditions to this part of the country in connection with field work on the ecology of bats and its relationship to rabies, under the auspices of the Pan American Sanitary Bureau, Zone II, World Health Organization, I have found bats of the species only in this cave. During the day, these bats take refuge in the extraordinarily large entrance chamber. The rest of the cave falls away spectacularly into a vertical abyss.

The specimens collected come from the walls that receive the faint light of the twilight zone. I used an extension ladder 6 meters long to capture them, taking them from their hiding places by hand or dropping them with a charge

of fine shot from a shotgun fired into the cavities of the stalactites in which they roost at a height of not over 15 meters above the floor. Above this distance, at least in winter and the beginning of spring, great numbers of bats may be heard squeaking, and countless drops of urine fall in a fine rain. I have never secured specimens from higher than 30 meters, the height of the roof.

Comparisons.—Tadarida yucatanica (Miller) is represented in the mammalian collections of the Institute de Biología of the Universidad Nacional Autónoma de México by 23 specimens from the ruins of Uxmal and from Merida, Yucatan, as well as from San José Carpizo, Campeche. From the Cueva del Abra, Tamaulipas, we have 33 specimens taken on the following dates: 12 and 17 November 1955; 7 October 1956; 11 January 1957; and 26 November 1958.

From my observations and from information given me by farmers of nearby villages, the bats forming this colony remain all year, and day after day may be seen issuing forth at dusk in great numbers; but from January to April the number of animals that emerge toward the cultivated plains about Ciudad Mante is such as to darken the canyon where the highway crosses, and a fine rain of urine falls for more than two hours. In summer and fall this situation is modified: the bats continue to emerge each afternoon, but not in such quantity.

At first I was inclined to consider the group of bats which did not leave during the whole year as a residual colony of *Tadarida brasiliensis mexicana*. However, on assembling all the existing material for cataloguing and study, the specimens from Tamaulipas and from the Yucatan Peninsula showed such a close similarity in external characters that I was inclined to assign both groups to the same species. This belief was corroborated by Robert W. Dickerman of the Minnesota Museum of Natural History, who had compared materials in the American Museum of Natural History, concluding that his material did not belong to any species currently known from the continental mainland.

Besides the similarity in external characters of both groups, the sedentary habits of the colony at Cueva del Abra lend further support to the idea that it belongs to the Yucatan species, since we have elsewhere explained (Málaga Alba and Villa R., 1957: 529–569) that *Tadarida yucatanica* is sedentary, in contrast to *T. b. mexicana*, a subspecies manifestly migratory.

Therefore, the great number of bats that take refuge in the Cueva del Abra in winter very possibly are *Tadarida brasiliensis mexicana*. Besides these, there have been reported from the same locality *Tadarida femorosacca* (Merriam) and "*Tadarida laticaudata ferruginea* Goodwin" (Dalquest and Hall, 1947: 245–248; Goodwin, 1954: 2–3). The type and paratypes of the latter were collected by William Z. Lidicker "in a cave 8 miles north of Antiguo Morelos," and from the location of the type locality I am inclined to think that it must be Cueva del Abra. No other cave known to the author is located 8 miles from Antiguo Morelos.

To judge by the description of "*Tadarida laticaudata ferruginea*" the coloration and the external and cranial measurements do not differ significantly from *T. yucatanica*. "M_1, viewed from crown surface, with hypocone expanded posteromedially into a broad heel, making tooth broader posteriorly than anteriorly" (Hall and Kelson, 1959: 204) has the same characteristics in the specimens from Tamaulipas as in those from Yucatan.

Coloration.—In the specimens from Cueva del Abra, the color of the upper parts is Vandyke Brown, with base of the pelage white (colors with capitalized names are from Ridgway, COLOR STANDARDS AND COLOR NOMENCLATURE, 1912). The underparts are Bister and the tips of the abdominal hairs are paler or Pinkish Buff, these hairs lacking the white base of the rest of the body pelage. The ears, feet and alar membranes are "Blackish Brown (2)." Placed side by side, the specimens from Cueva del Abra show no significant differences from those from the Yucatan Peninsula, nor from the description of "*T. l. ferruginea.*" In short, I do not find in my recently collected specimens the Wood Brown back which is claimed as the main difference between these two species. The ventral parts of my Yucatan specimens show less of the Pinkish Buff tipping.

Measurements.—In the accompanying Tables 1 and 2 are shown Arithmetic Mean (A.M.), Standard Deviation (S.D.), Cubic Deviation (C.D.), Biquadratic Deviation (Q.D.), Observed Maximum (Ma.) and Observed Minimum (Mi.) of the two samples.

As may be seen, there are no significant differences between the samples from the Yucatán Peninsula and from Cueva del Abra, Tamaulipas. Actually, neither are there any differences from the measurements given in the description of "*T. laticaudata ferruginea* Goodwin" (*op. cit.*), all of which fall within the range of individual variation.

TABLE 1.—*External measurements of sample bats*

VARIATES	A.M.	S.D.	C.D.	Q.D.	MA.	MI.
			From Yucatan Peninsula:			
Total length	99.1	5.1	1.4	1.7	104.0	80.0
Tail vertebrae	37.9	2.5	1.2	1.6	42.0	34.0
Hind foot	9.2	0.5	0.6	0.1	10.0	8.5
Ear from notch	17.5	1.2	7.2	1.3	20.0	15.0
Tibia	11.4	3.6	7.9	1.3	11.9	10.8
Forearm	41.4	6.0	5.2	1.6	42.7	40.0
Thumb	6.8	0.2	0.5	0.1	7.2	6.5
			From Tamaulipas:			
Total length	99.7	3.7	7.2	1.2	106.0	92.5
Tail vertebrae	37.2	2.7	6.5	1.3	44.9	32.0
Hind foot	9.0	0.9	0.5	0.1	11.1	7.0
Ear from notch	19.3	1.2	5.3	1.2	21.4	17.0
Tibia	11.7	6.2	7.6	1.2	13.2	10.7
Forearm	42.4	4.8	8.9	1.5	43.5	41.1
Thumb	6.8	0.5	0.9	0.1	7.8	6.0

How could *T. yucatanica* have reached Tamaulipas?

Naturally, any explanation I may give of the presence of the colony of Yucatan free-tailed bats in Tamaulipas is purely speculative.

It has already been remarked that one of the distinctive characteristics of *T. yucatanica* is its sedentary nature; its movements are strictly local and are not known to cover the enormous distances traveled by bats of the subspecies *T. b. mexicana*. It is incredible, therefore, that the colony in Cueva del Abra could have arrived through a shift during migration.

Rather, it seems that the hurricanes that often move from the Caribbean sea toward the mainland, at times with tragic consequences for the human population of the coastal plains, may have played the leading role in the movement of these animals, driving them from their hunting grounds in the Yucatan Peninsula, more or less violently, bringing them across the waters, and leaving them to seek an adequate refuge in the foothills of the Sierra Madre Oriental when that rocky mass weakened the cyclonic force of the storm. In the accompanying map (Fig. 1), the arrow marks the probable route that the ancestral bats may have followed accidentally. Similar cases have been observed on other occasions. Denny G. Constantine has informed me that in 1958 he observed "a large cave colony of *brasiliensis* carried away by a strong wind, against which they were flying."

TABLE 2.—*Skull measurements of sample bats*

VARIATES	A.M.	S.D.	C.D.	Q.D.	MA.	MI.
			From Yucatan Peninsula:			
Greatest length	17.1	3.1	8.2	1.4	17.6	16.4
Basal length	14.6	4.1	5.7	1.3	15.4	13.6
Basilar length	14.0	4.7	8.3	1.3	14.8	12.9
Interorbital constriction	3.7	0.1	0.3	0.1	4.1	3.5
Zygomatic breadth	9.8	0.2	0.4	0.1	10.3	9.5
Breadth of brain case*	8.4	0.2	0.2	0.1	8.9	8.0
Mandible	12.1	2.9	4.9	1.3	12.7	11.6
Maxillary toothrow†	6.4	0.2	0.9	0.1	6.7	6.1
Mandibular toothrow†	6.9	0.2	0.5	0.1	7.4	6.5
			From Tamaulipas:			
Greatest length	17.6	2.9	6.6	1.4	18.1	17.1
Basal length	14.9	2.9	5.6	1.2	15.5	14.3
Basilar length	14.4	3.0	5.8	1.2	15.1	13.9
Interorbital constriction	3.8	0.1	0.8	0.1	4.1	3.6
Zygomatic breadth	10.0	2.2	7.9	1.1	10.5	9.7
Breadth of brain case*	8.5	0.1	0.3	—	8.9	8.3
Mandible	12.4	2.3	4.9	1.2	13.0	12.0
Maxillary toothrow†	6.7	0.1	0.9	1.3	7.0	6.4
Mandibular toothrow†	7.2	0.1	0.7	0.1	7.6	7.0

* Above roots of zygomata. † Exclusive of incisors.

CONCLUSIONS

In Cueva del Abra, 10 km. NNE Antiguo Morelos, Tamaulipas, bats of the family Molossidae have been found, representing the species *Tadarida femorosacca* (Merriam), and it is presumed that *T. brasiliensis mexicana* (Saussure) occurs in great numbers during its period of winter emigration. *T. b. mexicana* apparently occupies by preference the high arch of the roof of the enormous

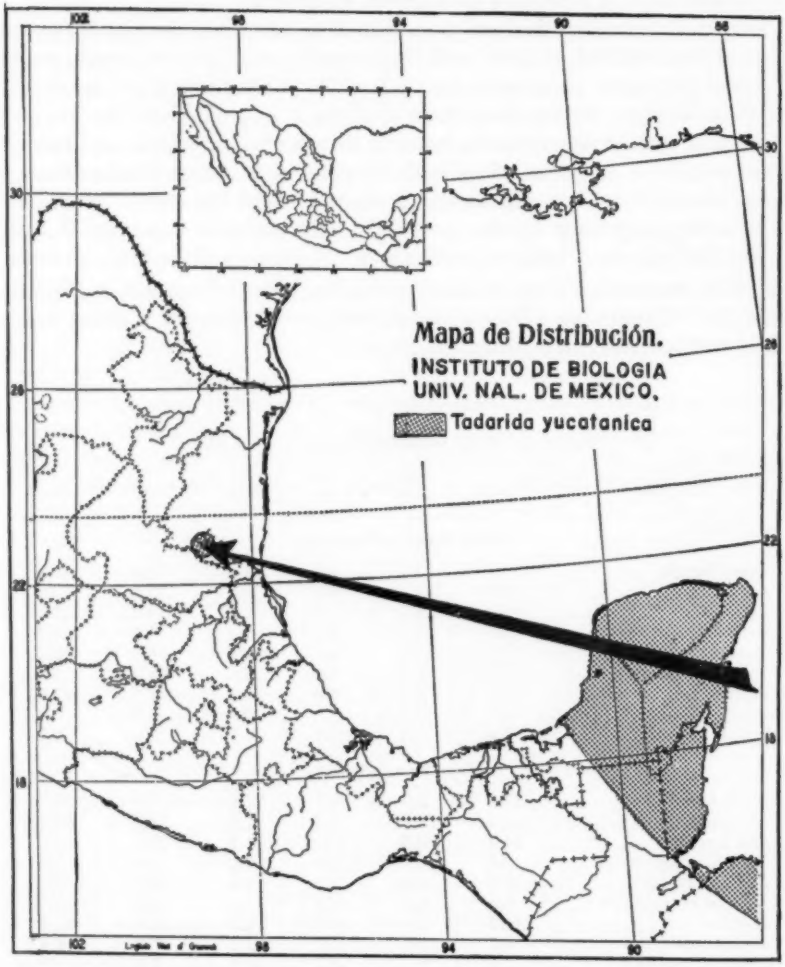

FIG. 1.—Possible course of dispersal of *Tadarida yucatanica* from the Yucatan Peninsula to Tamaulipas.

cave. Another numerous colony, which roosts in the hollows among the stalactites of the walls, as far as the faint twilight-zone penetrates, and which remains all year, proves to belong to the species *Tadarida yucatanica* (Miller).

"*Tadarida laticaudata ferruginea* Goodwin," whose type locality is given as 8 miles north of Antiguo Morelos (which may very well be Cueva del Abra), does not differ significantly from *T. yucatanica*. Its external and cranial measurements fall within the range of individual variation. Therefore, it falls into the synonymy of *T. yucatanica*.

Speculatively, it is thought that the Tamaulipas colony of *T. yucatanica* is descended from animals caught by hurricane winds at some point in the Yucatan Peninsula and thrust across the Gulf of Mexico and against the foothills of the Sierra Madre Oriental, where they found an adequate refuge in Cueva del Abra.

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FOSSIL *TADARIDA* FROM NEW MEXICO

By Barbara Lawrence

The material discussed herein was collected at New Cave (also known as Slaughter Cave) in the Carlsbad Caverns National Park. Denny G. Constantine, in a letter dated 19 May 1958, described the deposit as follows: "New Cave was until very recently mined for bat guano. Apparently a great portion of the very old guano deposit was removed. . . . The deposit layout on the floor of 'Fossil Alley' where the bones were collected, suggests the entire thing has been redistributed by water. I presume the matrix is decomposed bat guano. Nearby portions of the cave contain similar deposits, including bat bones, now covered with about ½" layer of flowstone, which is easily removed. Wing bones are most abundant at upper layers of the deposits, skulls and heavier bones being most abundant several inches lower."

It is a pleasure to name this new species for Dr. Constantine who recognized it as being distinct from *Tadarida brasiliensis mexicana*, which presently inhabits the region, and who supplied us with the material on which this paper is based.

Tadarida constantinei sp. nov.

Holotype.—M.C.Z. 49076, skull from New Cave, Carlsbad Caverns National Park, New Mexico, collected by Denny G. Constantine, 7 May 1958. The guano deposit in which the bones were found is dated "older than 17,800" years ago (Libby, Science, 120: 739, 1954).

Paratypes.—M.C.Z. 49063–49066, 49068, 49069, 49071, 49073, 49074, 49076, 49077, 49080, 49614–49620, all with the same data as holotype.

Diagnosis.—This form is characterized by its relatively great size and long, rather evenly rectangular skull.

Description.—The *Tadarida* that roosted in New Cave is referable to the *brasiliensis* group, from the several members of which it differs markedly in size. Probably in over-all dimensions it was about 10 per cent larger than the biggest of its modern relatives. The three mainland races of this group, *brasiliensis, mexicana* and *cynocephala,* are all somewhat larger than the island forms but differ so slightly amongst themselves that isolated specimens are often impossible to identify on other than geographic grounds. Schwarz (Jour. Mamm., 36: 106–109, 1955) has pointed out their general similarity and in agreement with him I find them not more than subspecifically distinct. Compared with these three races of *brasiliensis,* the skull of *constantinei* is so much larger that it does not overlap with them at all in standard length-breadth measurements. This conspicuous primary size difference is reinforced by certain additional differences in proportion which further emphasize the distinctness of this new species. Compared with *brasiliensis, mexicana* and *cynocephala,* the brain case is both narrower and lower in proportion to length of skull.

TABLE 1.—*Measurements of Tadarida constantinei and T. brasiliensis mexicana*

MEASUREMENT	CONSTANTINEI						MEXICANA				
	Holotype	No. spec.	Range, mm.	Mean, mm.	σ	V	No. spec.	Range, mm.	Mean, mm.	σ	V
Length of skull	17.4	19	16.5–17.4	17.0	0.235	1.38	19	14.5–15.6	15.0	0.242	1.61
Alveolar length of upper cheek teeth including canine	6.8	19	6.6– 7.1	6.82	0.159	2.33	19	5.9– 6.3	6.08	0.104	1.71
Alveolar width across molars	8.1	18	7.5– 8.1	7.82	0.158	2.02	19	6.6– 7.2	6.99	0.159	2.30
Height of brain case	5.8	19	5.6– 6.0	5.82	0.118	2.04	19	5.0– 5.8	5.51	0.209	3.79
Width of brain case	9.1	19	8.6– 9.3	8.96	0.153	1.71	18	8.0– 8.6	8.27	0.176	2.12
Ratio width of brain case to length of skull	52.0	19	50.0–55.0	53.1	1.57	2.96	18	54.0–58.0	55.3	1.45	2.62
Ratio height of brain case to length of skull	33.0	19	33.0–36.0	34.5	1.08	3.13	19	35.0–39.0	36.8	1.29	3.51
Length of jaw	—	19	12.6–13.3	12.8	0.239	1.87					
Alveolar length of lower cheek teeth including canine	—	19	7.2– 7.8	7.46	0.178	2.39					

This gives the skull of *constantinei* a rather evenly rectangular, flattened appearance, the more so because the rostrum is not narrowed proportionally and is relatively deeper. Ratios of breadth of brain case to length of skull computed from Shamel's figures (Proc. U. S. Nat. Mus., 78: 23–25, 1931) for 18 *brasiliensis*, 24 *mexicana* and 20 *cynocephala* confirm the close relationship of these three forms and show a maximum difference of only 0.2 in their means. Ratios of breadth to length, measured slightly differently, in the *constantinei* and *mexicana* at hand, show a difference of 2.2 in their means. The results are similar, when flatness of skull is compared; Shamel's measurements of *brasiliensis*, *mexicana* and *cynocephala* show a maximum difference of 1.0 in the means of the ratio of occipital depth to total length of skull. The means of related measurements taken on *constantinei* and the M.C.Z. series of *mexicana* differ by 2.3. This flattening of the skull in *constantinei* gives it a very characteristic appearance which even to the casual observer readily sets it apart from the *brasiliensis* group. In other cranial features the proportions of *constantinei* are much as in the three modern races.

Postcranially, the only significant differences found were in size. Detailed comparisons were made of 31 tibiae and 44 humeri of *constantinei* with the same elements of six *mexicana*. Since size was the only diagnostic feature found, further analyses of the other long bones were not undertaken.

Material examined.—In addition to the type series, other more fragmentary skulls and abundant postcranial material were available. For *brasiliensis*, Shamel's characters and measurements were used and direct comparisons were made with skulls of 19 *mexicana* from scattered localities in Oklahoma, Arizona, New Mexico, California and northern Mexico, four *cynocephala* from Louisiana, and three *brasiliensis* from Argentina and Chile, as well as skeletons of six *mexicana* from Oklahoma and Arizona.

Measurements.—Since the skulls all lacked bullae and many had the premaxillaries broken, length from the occipital condyle to the anterior border of the alveolus for the canine was substituted for total length and the same measurement taken on recent forms was used in computing ratios for purposes of comparison. For the same reason, height of brain case was taken from the glenoid fossa vertically to the dorsal surface of the brain case. Length of lower jaw is from the condyle to the alveolar margin of the first incisor. See Table 1.

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AGE AND REPRODUCTIVE CHARACTERISTICS OF MOUNTAIN POCKET GOPHERS IN COLORADO

By Richard M. Hansen

The general features of reproduction in pocket gophers are known to vary not only with different species but also within different geographic areas occupied by a single species. This paper presents some of the facts obtained on age and breeding characteristics of the mountain pocket gopher, *Thomomys talpoides*, in Colorado from August 1955 through September 1958.

The present study is based on the post-mortem examination of 1,738 mountain pocket gophers, of which 1,228 were examined internally for reproductive data. Samples were obtained for all seasons of the year at Livermore, Larimer County. The intermittent absence of snow cover facilitated trapping during the winter at Livermore. Most of the other samples were taken on Black Mesa, Gunnison County; Grand Mesa, Mesa County; and the Deep Lake area, Garfield County. In the latter areas the snow cover usually extends from October to June and is frequently 6 or more feet deep in late winter, and specimens were taken only during the snow-free seasons. The pocket gophers from the Livermore area were mostly taken from irrigated alfalfa fields, and those from other areas were taken on rangelands characterized by a mixture of forbs and grasses.

Some specimens were examined within several hours after death, but most of them were frozen as soon after capture as possible and examined later. When the condition of the specimen allowed, body weight and measurements were taken. Females were examined for the condition of teats and genital organs. The presence of a "pubic gap" and the number of placental scars and embryos were recorded. The crown-rump lengths of embryos and widths of the uterine horns were measured. Males were examined for condition of sex organs, size of testes, length of os penis, and a small number were examined for the presence of spermatozoa in the cauda epididymis.

AGE OF INDIVIDUALS

Since much can be learned of a population if its members can be correctly aged, special emphasis was placed on the investigation of age characteristics. Confusion has resulted because persons studying the reproductive habits of pocket gophers have either not recognized or used available criteria for correctly denoting the age of individuals examined. Some workers have used an arbitrary weight for aging pocket gophers as "adults" and "juveniles" (Miller, 1946; Tryon, 1947; Wood, 1949). In a study on the reproductive system of the male pocket gopher (*T. bottae*) in California, Gunther (1956) found that the size (weight) of the animals had little to do with the presence or absence of motile sex cells, and concluded that within the range of weights in his sample, it was impossible to judge sexual maturity on the basis of body weight. Tryon (1947) has shown that individually marked pocket gophers (*T. talpoides*), live-trapped

as young and recaptured in subsequent years, reached a rather stable weight by the time they were one year of age, and showed little increase in weight thereafter. Ingles (1949) live-trapped, marked and recaptured young pocket gophers (*T. monticola*) from May to October in California. One individual gained from 32 grams on 1 July to 100 grams on 15 August, exceeding the average weight of adult males for that date by about 10 grams. The others gained more slowly and their weights tended to level off about October. The average weights of adults trapped at Livermore did not vary significantly with the season (Table 1). The weights of young and adults frequently overlapped within a short time after the first young were trapped. Age determination cannot, therefore, be based on body weight except in the case of very young animals.

Average body lengths of adult males and females did not vary significantly with season, and the lengths of young five or six months old are not significantly different from adults (Table 2). Only very young animals can be told from adults on the basis of total body length.

Young pocket gophers in silky "immature" pelage can be told from adults. Bailey (1915) has described the first pelage of young pocket gophers and molting of adults. Morejohn and Howard (1956) have recently reported more accurately on patterns of molt progression and frequency of molt for the valley pocket gopher. Young pocket gophers from Colorado usually molt into an adult-type pelage in late August and September. Sexually immature animals that have acquired adult-type pelage cannot be distinguished with certainty from adults, and at this time of year there is already considerable overlapping of weights and body measurements of young and adults.

TABLE 1.—*Weights of pocket gophers trapped at Livermore (in grams)*

Mean date	Age	MALES			FEMALES		
		No.	Avg. ± S.E.	Range	No.	Avg. ± S.E.	Range
10 Jan.	ad.	7	136 ± 7.7	119–175	13	124 ± 3.8	100–150
22 Feb.	ad.	22	167 ± 6.6	104–218	27	137 ± 3.2	96–163
27 Mar.	ad.	24	170 ± 3.4	142–215	20	138 ± 3.4	110–163
15 Apr.	ad.	86	159 ± 6.6	120–206	49	136 ± 2.8	102–193
15 May	ad.	58	158 ± 1.9	116–190	36	135 ± 3.3	85–183
15 May	yg.	—	—	—	1	60 —	—
12 June	ad.	18	148 ± 5.0	111–178	25	136 ± 3.1	105–172
12 June	yg.	8	73 ± 4.5	54– 89	17	75 ± 3.1	50–101
15 July	ad.	2	172 —	157–187	7	148 ± 8.7	112–176
15 July	yg.	6	94 ± 9.4	74–137	10	97 ± 7.0	64–134
15 Aug.	ad.	9	158 ± 6.4	122–183	22	135 ± 4.0	105–174
15 Aug.	yg.	18	95 ± 5.6	55–128	27	107 ± 3.3	69–133
18 Sept.	ad.	9	176 ± 5.5	152–213	12	158 ± 3.2	141–182
18 Sept.	yg.	13	125 ± 5.9	86–157	23	121 ± 3.9	76–155
31 Oct.	ad.	2	153 —	140–146	1	153 —	—
31 Oct.	yg.	3	128 —	113–145	9	124 ± 4.1	101–135
15 Nov.	ad.	6	158 ± 10.1	122–183	4	150 —	137–168
15 Nov.	yg.	7	150 ± 6.5	130–167	12	136 ± 5.8	110–177
22 Dec.	ad.	2	165 —	163–167	2	155 —	154–155
22 Dec.	yg.	7	154 ± 3.9	137–168	8	143 ± 6.3	113–169

Hisaw (1924: 93) has shown that the pubic symphysis is absorbed in young females approaching adulthood. He states, "This absorption is correlated with the general activities of the reproductive system preceding pregnancy and is usually complete before copulation . . . and in no instance has there been any evidence to indicate that the symphysis is restored after parturition." The presence of a pubic gap is sufficient evidence to indicate a female has approached or undergone at least one breeding cycle. Young females captured at Livermore could be distinguished from adult females by the presence of a pubic gap and the width of the pubic gap until late February. None of the 12 young females examined in November showed signs of developing a pubic gap. However, in the latter part of December, eight young females were examined; one had a narrow gap and one had developed a "notch" in the pubic symphysis. In January, nine young females were examined; only two had developed a "notch" in the pubic symphysis. A sample of 21 young females was examined in February, six had "notches" and four had narrow pubic gaps. In late March the young females could not always be told from adults by the relative width of the pubic gap, and only one female out of a sample of 24 did not have at least a "notch" in the pubic symphysis. In the April sample of 47 females, only one did not possess a pubic gap. All females approaching one year of age or older possessed pubic gaps in the remaining samples. In most cases there was an enlargement of the uterine horns at the time the pubic gap formed, but this was not always true. In February, one young female without a pubic gap possessed uterine horns that were 3.5 mm. wide, and another whose uteri were 1.0 mm. wide had developed a "notch." However, most young fe-

TABLE 2.—*Total lengths of pocket gophers from Livermore (in mm.)*

Mean date	Age	MALES			FEMALES		
		No.	Avg. ± S.E.	Range	No.	Avg. ± S.E.	Range
10 Jan.	ad.	7	223 ± 3.9	206–238	12	219 ± 3.0	200–232
22 Feb.	ad.	23	227 ± 2.5	207–247	27	225 ± 1.7	203–242
27 Mar.	ad.	23	226 ± 1.7	215–245	19	219 ± 1.3	211–230
15 Apr.	ad.	88	219 ± 1.1	193–249	49	215 ± 1.9	196–241
15 May	ad.	60	223 ± 1.2	203–241	36	216 ± 1.4	200–234
15 May	yg.	—	—	—	1	158 —	—
12 June	ad.	18	228 ± 2.1	212–242	25	224 ± 1.4	204–240
12 June	yg.	8	186 ± 3.7	166–200	17	191 ± 3.6	163–219
15 July	ad.	1	236 —	—	7	232 ± 4.0	217–251
15 July	yg.	7	204 ± 4.3	185–220	10	207 ± 4.8	183–235
15 Aug.	ad.	9	240 ± 3.5	225–258	22	229 ± 2.4	215–255
15 Aug.	yg.	18	211 ± 3.8	163–231	27	214 ± 2.4	189–236
18 Sept.	ad.	9	237 ± 3.4	229–247	12	232 ± 2.9	219–249
18 Sept.	yg.	13	219 ± 2.9	202–239	23	215 ± 2.3	188–243
31 Oct.	ad.	2	223 —	219–227	1	221 —	—
31 Oct.	yg.	3	214 —	210–220	9	211 ± 3.0	197–221
15 Nov.	ad.	4	235 —	232–238	4	227 —	220–231
15 Nov.	yg.	6	225 ± 2.9	216–237	8	224 ± 4.6	201–242
22 Dec.	ad.	2	233 —	230–235	2	230 —	228–230
22 Dec.	yg.	7	223 ± 3.2	210–233	8	221 ± 1.8	198–230

males whose uteri were 2.0 mm. or larger showed some evidence of the formation of a pubic gap in February and March. Therefore, it appears that a natural method for aging female pocket gophers is to classify those with a pubic gap as adults and those without a pubic gap as young.

A characteristic that is of limited value in determining age and state of reproductive activity is the diameter of the uterine horn, measured at its proximal end (Table 3). The uteri remain small in young females from the time of weaning until an age of six to seven months. At this age, the uteri begin to enlarge rapidly and soon approach the same size as those of adults. The enlargement of the uteri of young females begins at about the time the pelvic gap is formed. The uteri of both adults and young enlarge at about the same time of year, just prior to the breeding season. Following breeding and parturition, the uteri of adult females become smaller in diameter but are usually larger than those of young females less than five or six months of age.

The correct determination of age is slightly more difficult for male pocket gophers than for females. The position, size and condition of the testes have been used as indicators of breeding and age in many kinds of mammals. The morphological features of the reproductive system of the male pocket gopher have been described by Hill (1937) and more recently by Gunther (1956). In the breeding season the testes of adult males form swellings on either side of the penis and anus in the large inguinal canals (Hill, 1937; Tryon, 1947). The scrotum (*sensu stricto*) contains only the cauda epididymis and both features become reduced in size and obscure during the non-breeding season.

TABLE 3.—*Widths of uterine horn of pocket gophers from Livermore (in mm.)*

Mean date	Age	No.	Avg. ± S.E.	Range
10 Jan.	ad.	1	3.0 —	———
10 Jan.	yg.	9	1.4 ± 0.1	1.0–2.0
22 Feb.	ad.	6	3.1 ± 0.4	2.0–4.3
22 Feb.	yg.	20	2.0 ± 0.2	1.0–4.0
27 Mar.	ad.	20	3.3 ± 0.3	2.0–6.0
15 Apr.	ad.	47	3.7 ± 0.2	1.2–9.2
15 May	ad.	35	4.3 ± 0.3	1.9–8.2
15 May	yg.	1	0.7 —	———
12 June	ad.	25	3.1 ± 0.2	1.6–5.4
12 June	yg.	17	1.0 ± 0.1	0.5–1.5
15 July	ad.	7	2.7 ± 0.2	2.0–3.0
15 July	yg.	10	1.1 ± 0.1	0.8–1.5
15 Aug.	ad.	22	2.2 ± 0.1	1.0–3.0
15 Aug.	yg.	27	1.2 ± 0.1	0.9–2.3
18 Sept.	ad.	12	2.3 ± 0.1	1.9–2.6
18 Sept.	yg.	23	1.1 ± 0.1	0.9–1.5
31 Oct.	ad.	1	2.0 —	———
31 Oct.	yg.	9	1.0 ± 0.1	0.9–1.1
15 Nov.	ad.	5	1.9 —	1.5–2.0
15 Nov.	yg.	12	1.0 ± 0.1	1.0–1.5
22 Dec.	ad.	2	2.2 —	2.0–2.5
22 Dec.	yg.	8	1.1 ± 0.1	1.0–1.5

Both testes usually occupy the same corresponding position but, in sexually active males, one testis may lie in a different position than the other. The sexually active male may be capable of controlling the position of the testes (Miller, 1946). In sexually inactive young and adult males the testes lie in the abdominal cavity, but only slightly anterior to the position occupied by the testes of most sexually active males.

The size of the testes is useful as an indicator of age (Table 4). The testes of young males are spherical in shape, firm and about 5–7 mm. long from the time of weaning until the young are about five or six months old. The length of testes of young males increases rather rapidly from November to December, when they can no longer be distinguished from those of adults. The testes of both young and adults increase in size, just prior to the breeding season, more rapidly than do the accessory sex organs. In adults there is a gradual decrease in size of all sex glands following the breeding season. Therefore, by careful examination it is sometimes possible to tell if males are entering or leaving the breeding season by the size of the testes in relation to the accessory sex organs. Young males can also be told from adults by their smaller testes.

The condition of the testes is also diagnostic of breeding condition and age. The testes of adult males decrease in size and become soft, flabby and dark colored following the breeding season. This "amorphous" condition of the testes occurs prior to the reduction in size of the accessory glands and fat bodies, and is maintained until the testes of the adult enter the growth period prior to the next breeding season. The testes of young males remain firm, turgid and light colored from the time of weaning until the young attain

TABLE 4.—*Reproductive characters of male pocket gophers from Livermore*

Mean date	Age	LENGTH OF TESTES, MM.			LENGTH OF BACULUM, MM		
		No.	Avg. ± S.E.	Range	No.	Avg. ± S.E.	Range
10 Jan.*	ad.	7	17.9 ± 0.8	15–20	6	15.1 ± 0.9	13.1–18.6
22 Feb.†	ad.	23	22.3 ± 0.8	9–27	17	18.2 ± 0.4	15.0–21.3
27 Mar.	ad.	24	22.9 ± 0.3	20–25	21	19.5 ± 0.3	17.5–22.0
15 Apr.	ad.	88	20.1 ± 0.9	16–22	57	19.5 ± 0.2	15.9–22.3
15 May	ad.	57	18.5 ± 0.2	15–20	28	18.8 ± 0.5	14.0–24.0
12 June	ad.	18	16.2 ± 0.4	12–20	16	19.9 ± 0.3	18.0–21.6
12 June	yg.	8	4.5 ± 0.2	4– 5	6	8.7 ± 0.4	7.8–10.4
15 July	ad.	2	16.0 —	15–17	2	21.0 —	21.0–21.0
15 July	yg.	7	5.0 ± 0.5	3– 6	7	9.7 ± 0.6	8.0–11.0
15 Aug.	ad.	8	11.6 ± 0.4	10–14	9	19.8 ± 0.8	16.4–23.8
15 Aug.	yg.	19	4.9 ± 0.2	3– 7	12	9.2 ± 0.5	6.3–11.7
18 Sept.	ad.	9	12.4 ± 0.4	11–14	9	19.8 ± 0.3	18.6–21.0
18 Sept.	yg.	13	5.8 ± 0.2	5– 8	11	13.0 ± 0.4	10.1–15.1
31 Oct.	ad.	2	12.0 —	12–12	2	17.3 —	15.8–18.8
31 Oct.	yg.	3	6.3 —	6– 7	3	12.5 —	10.9–14.2
15 Nov.	ad.	6	11.3 ± 0.2	10–13	3	19.3 —	18.4–20.0
15 Nov.	yg.	7	10.0 ± 0.9	7–14	6	13.9 ± 0.3	13.0–15.0
22 Dec.	ad.	2	18.0 —	18–18	2	19.7 —	19.3–20.2
22 Dec.	yg.	7	15.6 ± 1.0	8–22	6	14.2 ± 0.4	13.2–15.6

* Sample includes one adult and five young.
† Adults and young could not be distinguished with certainty.

puberty. Therefore, its is possible to distinguish adult from young males when the testes of both are nearly the same size in the fall of the year, in Colorado.

Another useful characteristic for distinguishing males that have completed a breeding cycle from those which have not is the length of the os penis (Table 4). The length of this bone increases slowly in relation to age (size). There does not appear to be any overlap in the lengths of the bacula of old and young males before the young are about eight or nine months old and are approaching breeding condition. Therefore, if all the available criteria for determining age in males are used, it is possible to distinguish with certainty the males that have not bred from those that have approached or undergone at least one breeding cycle.

TABLE 5.—*Sex and age ratios of* 1,738 *mountain pocket gophers collected in Colorado, from August 1955 through September 1958*

LOCALITY AND MONTH	ADULTS			YOUNG		
	Ad. ♂♂	Ad. ♀♀	Total	YY ♂♂	YY ♀♀	Total
Black Mesa:						
*June	10	15	25	—	—	—
*July	15	21	36	8	5	13
*August	13	27	40	31	24	55
†September	31	30	61	—	—	61
†October	49	50	99	—	—	71
Grand Mesa:						
*July	36	51	87	6	17	23
†July	59	81	140	—	—	78
*August	14	23	37	15	6	21
*October	13	19	32	4	1	5
Deep Lake Area:						
*June	10	7	17	—	1	1
*August	16	17	33	19	26	45
Other Localities:						
*April	10	14	24	—	—	—
*May	25	22	47	—	—	—
*June	5	8	13	1	4	5
*August	2	4	6	6	15	21
*Livermore**:						
January	1	3	4	6	10	16
‡February	23	27	50	—	—	—
March	24	20	44	—	—	—
April	88	20	137	—	—	—
May	60	41	101	—	1	1
June	18	25	43	8	17	25
July	2	7	9	7	10	17
August	9	22	31	19	27	46
September	9	12	21	13	23	36
October	2	1	3	3	9	12
November	3	5	8	7	12	19
December	2	2	4	7	8	15
TOTALS:	549	608	1152	160	216	586

* Each specimen autopsied.
† Sex of adults determined externally, sex indeterminate for young; no specimens were examined internally.
‡ Both adults and young included together in February samples.

The time interval when the public gap is forming in females is considered to be that stage of sexual development called puberty, which also is characterized by an increased rate of development of the internal sex organs. In young male pocket gophers, puberty is reached when the sexual organs show an increased rate of growth and development just prior to the first reproductive period. Before puberty is reached, the animals are classified as "young" and following puberty they are "adults."

In the field, or in live animals, it is not always possible to examine specimens internally, but it was found that adult males can be distinguished from young by observing the length or size of the os penis by palpation. In actual practice, males are classed as adults as soon as the os penis is indistinguishable from that of the young; this is usually the case after the young are six or seven months of age. The presence or absence of a pubic gap in females is more easily detected by external examination. It becomes increasingly difficult to tell adults from young as development proceeds.

SEX RATIO

Sex determinations were made on 1,528 specimens and the over-all sex ratio was 54 per cent females (Table 5). Adults from September through March were 51 per cent females, which does not depart significantly from a 50–50 ratio. However, the sex ratio of adults in April and May was 41 per cent females, and from June through August the ratio was 61 per cent females. The low frequency of adult females in April and May was correlated with preg-

TABLE 6.—*Breeding characteristics of adult female pocket gophers from Colorado*

LOCALITY AND MONTH	SAMPLE SIZE, NO.	GRAVID, NO.	EMBRYOS		POST PARTUM, NO.	PLACENTAL SCARS*, MEAN ± S.D.
			Number, Mean ± S.D.	Size in MM., Mean ± S.D.		
Black Mesa:						
June	15	1	6 —	20 —	7	4.1 ± 1.3
July	21	1	2 —	10 —	17	4.6 ± 1.5
August	27	—	———	———	7	5.1 ± 0.9
Grand Mesa:						
June	2	2	4.5 —	13.5 —	—	———
July	49	6	4.5 —	16.6 —	34	4.4 ± 1.3
August	23	1	6 —	26 —	13	4.5 ± 1.1
October	19	—	———	———	14	4.2 ± 1.0
Deep Lake:						
June	5	—	———	———	4	4.0 —
August	19	1	5 —	20 —	2	3.5 —
Livermore:						
March	20	1	7 —	5 —	—	———
April	49	15	6.7 ± 1.2	12.8 ± 9.7	1	6 —
May	41	6	6.0 —	15.3 —	18	6.5 ± 1.3
June	25	10	6.5 ± 0.7	11.2 ± 4.2	15	5.4 ± 1.4
July	7	—	———	———	7	7.3 ± 1.2
August	22	—	———	———	17	6.5 ± 1.4

* Group comparison of numbers of embryos and placental scars shows no significant difference for a given locality.

nancy, parturition and early postnatal care of the young, suggesting that females are less active in repairing openings in their burrow system and were trapped less frequently than their actual occurrence in the population. The lower frequency of capture of gravid females to post-partum females emphasizes this characteristic (Table 6). Miller (1952) suggested a similar explanation to account for a preponderance of males in his samples. The marked increase of adult females from June through August was correlated with late postnatal care of young, and suggests that females are more active in repairing openings in their burrow systems and are easier to trap. An even sex ratio between adults returns in September, at a time when the young have dispersed from the female's burrow. Therefore, the sex ratio of adults, as revealed by trapping, can be influenced by the seasonal activity cycle and it would not be unusual to have a preponderance of females in a sample taken during the height of the season characterized by late post-natal care of young by females.

AGE RATIO

Young and adults could be distinguished with certainty from April through January. In the months of February and March the young born the previous summer were difficult to distinguish from adults; for statistical purposes they are treated as adults.

The age groupings of a population may be indicative of survival if the population density is stationary and if there is a constant birth rate. The data from the Livermore area provide the best indication of survival since samples were taken at all seasons of the year. These data show that about 75 per cent of the population, at the time of breeding, consists of individuals born the previous reproductive season, and 25 per cent are two years old or older.

BREEDING SEASON

The reproductive condition of females for each month is summarized in Tables 3 and 5. The uterine horns attained their maximum size in May in the Livermore population. Apparently the width of the uterine horn attained its maximum size when the population contained the highest incidence of near-term and recently post-partum females. The gestation period for pocket gophers (*Thomomys*) is probably about 28 days (Scheffer, 1938). The first pregnant female from Livermore was trapped on 29 March; the first post-partum female on 14 April; and the last pregnancy was observed on 15 June. Therefore, breeding starts about the middle of March and extends to at least the middle of May. The testes attained their maximum size at about the time breeding started but steadily decreased throughout the most active part of the breeding period (Table 4). The breeding season of pocket gophers from Black Mesa, Grand Mesa and the Deep Lake area appears to be extended over a longer period of time than at Livermore. Pregnant females have been recorded as late as 24 July on Black Mesa, 1 August on Grand Mesa, and 16 August at the Deep Lake area. The latest observed pregnancy from any of the other localities in Colorado was 26 June.

The earliest date young were trapped was 18 May at Livermore, 6 June at Black Mesa, 12 June at Grand Mesa, and 20 June at Deep Lake. The age ratios shown in Table 5 from Black Mesa are probably not representative of the population for June, since no young were included in this sample. In the early part of June 1957, at the time of snowmelt and shortly thereafter, several young were found dead in snownests on top of the ground. Similar observations were repeated in late June 1957, on Grand Mesa, at the time of snowmelt. Therefore, some young pocket gophers are born prior to snowmelt at the higher elevations in Colorado. These observations indicate that the reproductive cycle is initiated at about the same time in the high mountain areas as in the foothill regions. However, the breeding season appears to be of longer duration at the higher elevations.

A limited number of males (about 60) were examined for the presence of spermotozoa in the cauda epididymis. Spermatozoa were present in all adult males examined that were taken in May, June and July. Spermatozoa were present in two adult males taken at Grand Mesa on 1 August, but were absent in the seven other adults examined. Spermatozoa were absent in all young males examined between 14 July and 3 October, and were absent in all adult males taken in September and October. The presence or absence of spermatozoa roughly correlated with the turgidity of the testes in adults; spermatozoa were absent in most specimens with soft testes.

LITTER SIZE

The data in Table 7 show that the average litter size varies with locality, and perhaps from season to season. The pocket gophers from Livermore averaged significantly more young per litter than those from any other locality. Wirtz (1954) reported the litter size of pocket gophers taken about 40 miles north of Livermore, at a slightly higher elevation, averaged 4.8 per female, which is fewer than those observed at Livermore in this study. M. W. Cummings (MS report, 1946) examined several hundred females trapped in the same general area on Grand Mesa as those of the present study, and reported significantly fewer young per litter than were observed in this study.

Miller (1946) reported that fertility in females increased with weight (age) to an optimum, and then declined. In this study there was no significant correlation between the size of the female and the litter size (Table 8). Total body length has a much smaller coefficient of correlation than body weight and, therefore, should be a more reliable index to age. Pregnant females averaged significantly heavier (147 grams vs. 137 grams, $p = .05$) than other adult females; but the weights of those with litters of six or less averaged the same as those with seven or more.

The frequency of resorption and proportion of fetuses affected appears to be very low. It is not always possible to recognize instances of resorption by gross examination during the early stages of pregnancy. However, eight resorbing embryos were observed in six different females from Livermore in the months of April, May and June. This was about 4 per cent of all embryos examined.

No resorbing embryos were recorded from any of the other localities. These data do not indicate any trend in prenatal mortality in relation to the stage of the reproductive cycle.

Wood (1949) and Miller (1946) have shown a definite correlation between the ovarian cycle and subsequent fertility for pocket gophers.

NUMBER OF LITTERS

There appears to be no evidence of more than one annual litter per female for the mountain pocket gopher (*T. talpoides*) in the Rocky Mountain region (Tryon, 1947; Wirtz, 1954; C. M. Aldous, MS, 1957; and Cummings, MS, 1946).

The trapping of pregnant females from the same tunnel with young pocket gophers has been interpreted as conclusive evidence that females produce more than one litter a year (Horn, 1923; Wight, 1930; Burt, 1933). The females were reported to be lactating in most instances. However, in the examination of a large number of females during the height of the breeding season in Colorado, it was impossible to determine with certainty post-partum females from pregnant females by the appearance of the mammae. Furthermore, some pregnant females produced an exuding liquid, by milking with forceps, while some post-partum females did not. Almost every possible combination of adult males, adult females, and young have been recorded in a study of plural occupancy of pocket gopher burrow systems in Colorado (Hansen and Miller, 1959). More than one adult female per burrow system has also been recorded in California by Miller (1946). Therefore, it does not appear that a great deal

TABLE 7.—*Litter size of mountain pocket gophers in the Rocky Mountain region*[*]

LOCALITY, AUTHORITY	YEAR	SAMPLE SIZE	AVG. ± S.E.
Livermore:			
Present study	1956–57	86	6.4 ± .18
Laramie, Wyo.:			
Wirtz, 1954	1952–53	—	4.8 —
Grand Mesa:			
Present study	1956–57	33	4.4 ± .21
Grand Mesa:			
Cummings, 1946	1942	342	3.5 —
	1943	328	3.8 —
	1945	—	3.7 —
	1946	—	3.2 —
Black Mesa:			
Present study	1955–57	33	4.7 ± .24
Turkey Creek, Colo.:			
Present study	1957	12	4.9 ± .14
Wasatch Plateau, Utah:			
Aldous, 1957	1942–56	400?	3.3 —
Bridger Mountains, Mont.:			
Tryon, 1947	1941–46	—	4.4 ± .13

[*] Based on counts of embryos and placental scars.

of reliability can be placed on determinations of brood frequencies based on plural captures of pregnant females and young.

Remarks: Bond (1946) has pointed out that soils are more friable following periods of precipitation and possibly the success of gophers meeting and mating is influenced by this factor. Dixon (1929) stated "the abundance of nutritious green food starts the gopher breeding" and in alfalfa fields in central California females in some instances produce three broods in one year. Storer (1942) and Miller (1946) have emphasized the importance of green vegetation in maintaining continuous year-round breeding. Miller (1946, 1948) further emphasizes the favorability of moderate temperatures and adequate soil moisture. He found that breeding was significantly greater in the summer on irrigated alfalfa fields than on non-irrigated lands and states, "These findings strongly indicate a nutritional factor in breeding, probably a vitamin." Scheffer (1938) pointed out the importance of favorable food and other environmental relations in pre-natal mortality. Studies conducted in the Huntington Lake Region, California, by Ingles (1952) have shown that breeding takes place while the ground is too wet for digging and when practically no green vegetation is in evidence.

At Livermore, the increased rate of development of the sex organs began in December. Presumably the same is true for gophers living in the high mountains. At Livermore, the least amount of green vegetation is available from December through March, and the stomachs of trapped pocket gophers contained the highest amount of roots (Ward, 1960). The amounts of green vegetation consumed increased rapidly in the spring at all localities and remained high throughout the vegetative growing season (*ibid.*). Therefore, at Livermore, increased development of the sex organs begins and breeding takes place when gophers are eating mostly alfalfa roots.

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TABLE 8.—*Relationship between total body length of females and litter size of pocket gophers from Livermore, Colorado**

NO. OF YG. PER LITTER	NO. OF FEMALES IN SAMPLE	AVG. TOTAL LENGTH, MM.	EXTREMES
3	2	210	210–210
4	6	225	204–241
5	8	219	204–234
6	28	221	204–235
7	31	223	197–255
8	7	226	216–232
9	4	230	219–251
10	1	215	———

* Based on numbers of embryos and placental scar counts from March through August.

Cattle Company, Livermore, and to Sydney Tibbets, Livermore, for access to their properties for trapping pocket gophers. Without their help and information this study could not have been completed.

SUMMARY

Data on 1,738 specimens of the mountain pocket gopher, *Thomomys talpoides*, were collected from (*a*) the vicinity of Livermore, Larimer County, during all seasons of the year; (*b*) on Grand Mesa, Mesa County, Black Mesa, Gunnison County, and the Deep Lake area, Garfield County, during the snow-free seasons; and (*c*) smaller samples from scattered localities along the foothill regions of east-central Colorado during the spring and summer. Qualitative and biometric analysis of the data indicated:

1. Only very young animals can be distinguished from adults by weight and body size. Young approach adult size when they are five to six months old. The weights and body lengths of adults do not vary significantly with season.

2. The formation of a pubic gap was found to take place when young females were from nine to twelve months old, at a time when the internal sex organs showed an increased rate of development. The uteri of both adults and young enlarge at about the same time of year, and attain maximum size in May, when the population contains the highest incidence of near-term and recent post-partum females.

3. The differences in condition of sex glands, length of testes, and length of the os penis can be used to distinguish adult males from young males that have not undergone a breeding cycle.

4. Young pocket gophers did not reproduce until they were about one year old.

5. A preponderance of males was observed when the majority of the females were pregnant or engaged in early post-natal care of young; while a preponderance of females was trapped when most females were engaged in late post-natal care of young. Equal sex ratios were observed during other periods.

6. About 75 per cent of the population, at the time of breeding, consists of individuals born the previous reproductive season and 25 per cent are two years or older.

7. Breeding begins at about the middle of March, at most localities, and extends to at least the middle of May in the Livermore area, and the middle of June at some of the higher mountain areas.

8. Litter size averaged 6.4 young per female at Livermore, 4.9 per female at Turkey Creek, 4.7 on Black Mesa and 4.4 on Grand Mesa.

9. There was no significant correlation between litter size and size (weight and length) of the female.

10. Less than 4 per cent of the embryos examined were found resorbing, and no seasonal trend was noted.

11. Conclusive evidence was presented that an adult female bears only one litter each year.

12. The abundance of roots in the diets of pocket gophers was shown to be positively correlated with sexual development and breeding.

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DENTITION AS AN AID IN UNDERSTANDING AGE COMPOSITION OF MUSKRAT POPULATIONS

By Maurice M. Alexander

The practice of aging a sample from an animal population has become a standard procedure in most wildlife studies. Because of its near universal distribution and relative abundance, the muskrat, *Ondatra zibethicus*, has received considerable attention and several good aging techniques have been developed. One of these techniques that is useful in the late winter to early spring period is the measurement of the zygomatic breadth (Alexander, 1951). This measurement has been shown to vary with age alone although some sexual differences have been noted in one area (Sather, 1956).

Success in the use of this technique, as with any mensural characteristic, depends upon the accuracy with which the measurement can be made and also in the accurate location of the dividing point that separates the age groups.

Muskrats vary between and within geographic locations. In the use of the zygomatic breadth as an age indicator, it is quite obvious that in a sample taken from a stream where the entire group is rather small, the dividing point between young and adults would be lower than in a sample of the generally larger marsh muskrats. Different marshes would also vary in this point. The correct dividing point should be determined for each habitat by aging a sample of 150 or more muskrats by another aging technique early in the season and plotting zygomatic breadth measurements against age. The most logical time to measure the zygomatic breadth is immediately after the pelt has been removed. An accurate measurement can be made on a fresh carcass if a fairly uniform pressure is used in applying the calipers. When the carcass becomes old and the head dry, the thin tissue over the arches often becomes more irregular and it is sometimes necessary to scrape the arches to determine the point of maxi-

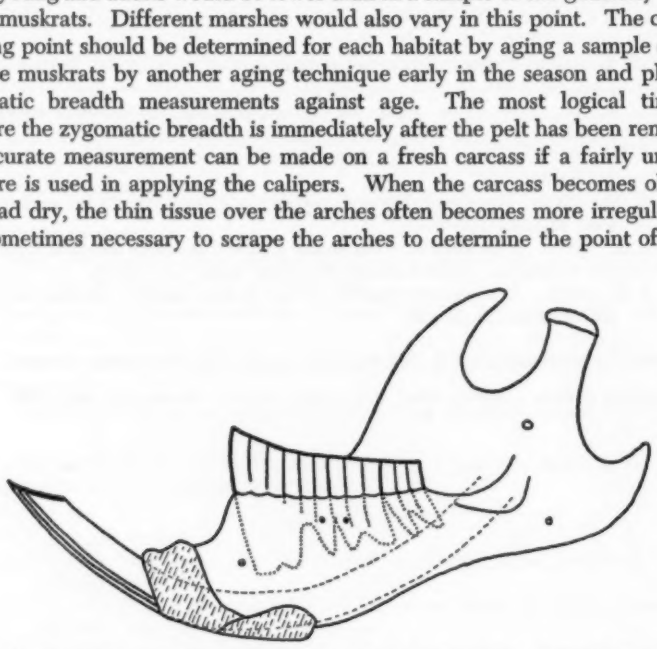

Fig. 1.—Proximal view of the right lower jaw showing the ending above the bone line of the anterior fluting of the first molar.

mum breadth. Skulls that have been cleaned before measurement undergo some shrinkage, most of which occurs in the first five days (unpublished data). Therefore, there is an advantage in determining the dividing point under the same conditions as will apply in actual practice. Since carcasses are most likely to be fresh, other measurements should be corrected for differences due to dried tissue or shrinkage.

In handling many skulls, one learns to sense their relative age from general appearance. This is based on many characteristics, several of which cannot be measured, and a few not even adequately described. These characteristics include the height and curling of the lambdoidal crest, the massiveness of the zygomatic arches, the roughness of the dorsal surface, the length of the temporal process, the appearance of the sutures, the cranial width : zygomatic breadth ratio, and dental wear and extrusion. These were all measured or described carefully in an attempt to find another characteristic of value in aging. A high degree of reliability was found in none of them.

The characteristic that offered the most encouragement was the first lower molar tooth. Gould and Kreeger (1948) used the upper molar as a criterion in selecting their advanced-age group. However, the extrusion and wear of the lower molars leave identifiable characteristics at an earlier age, approximately at the point of separation of the subadults from the adults. This characteristic is the appearance of the end of the first proximal fluting of the first lower molar at or above the bone line (Fig. 1). An associated curving is visible at the base of the anterior surface of this tooth, which was not present in the subadult. The reader is referred to Galbreath (1954) for a description of the growth and development of the teeth. Sather (1954), in his study of the Nebraska muskrat, found that 58 known-age specimens could be aged by the appearance of the end of the first fluting of the first upper molar. When F. C. Dean (unpublished Ph.D. thesis, Syracuse Univ., 1957) analyzed his data on upper molar characteristics, he found no evidence that this characteristic was of great value for central New York muskrats. Therefore, I continued with the evaluation of the lower molar.

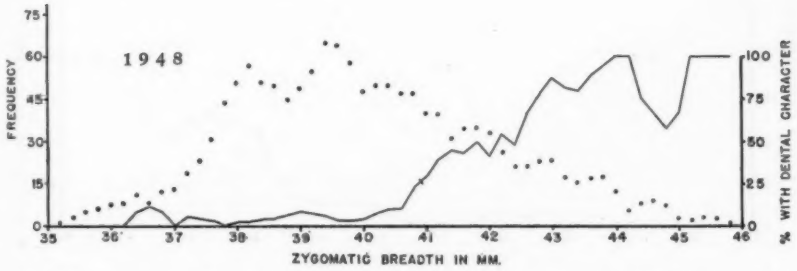

FIG. 2.—Frequency distribution of zygomatic breadth measurements and percentage of each size class possessing the dental characteristic for 454 muskrats in 1948; data smoothed by 3-point moving sums.

It is not expected that this dental age-characteristic would be used by a marsh manager in actual aging practice. Instead, its use will assist the manager or investigator in locating the dividing point in the zygomatic breadth measurements which will separate age classes.

This idea was tested in 1951 on a small sample of 59 muskrat skulls. Eighteen were called adults, based on characteristics of the first lower molars. The dry skulls were aged by zygomatic breadth measurements and 18 again were called adults. The two adult characteristics agreed on 15 individuals.

A more thorough study was made of the 1948 sample of 454 skulls from the Montezuma National Wildlife Refuge. The total height and the height of the base of the first fluting of both the upper and lower first molars were measured. Great variations were found in these measurements, so the evaluation was made on a have or have-not basis. Figure 2 shows the distribution of the zygomatic breadths of the 454 skulls. These had been remeasured and corrected for skull shrinkage to simulate fresh head conditions. The graph has been smoothed by using 3-point moving sums of 0.2-mm. classes. This overcomes any possible 0.1-mm. errors in reading the vernier calipers and the errors inherent in adding constants to correct for shrinkage. In this same figure, smoothed in the same manner, is a graph giving the percentage of each class, possessing the dental characteristic described above, the closure of the first proximal fluting at or above the bone line for the first lower molar. The corrected dividing point for 1948 is 40.9 mm.; at this point the dental characteristic is present in 25 per cent of the class. This graph of the percentage having the dental characteristic in each size class increases rapidly until it reaches approximately the 50 per cent level. It tends to level off for the next 1.5-mm. skull-breadth increase, and then

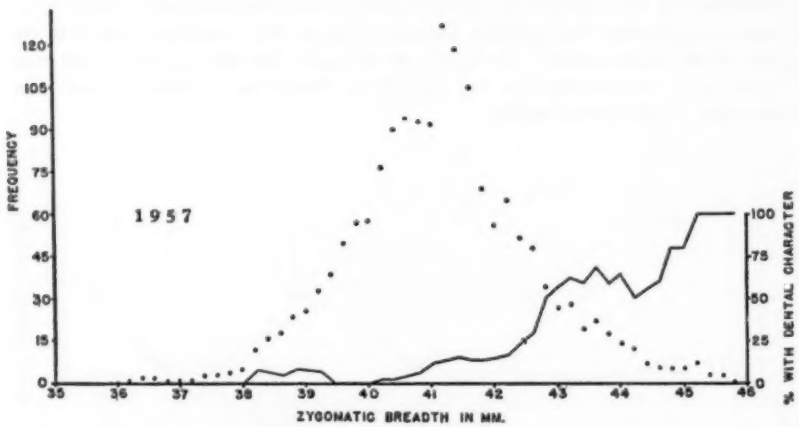

FIG. 3.—Frequency distribution of zygomatic breadth measurements and percentage of each size class possessing the dental characteristic for 551 muskrats in 1957; data smoothed by 3-point moving sums.

again increases rapidly to the 100 per cent level. The fluctuations seen in the largest size classes are due to the small sample in these classes.

Dean, in his study of 752 dry skulls taken from the Montezuma Refuge in 1954, established the dividing point at 40.9 mm. When this is corrected for shrinkage it equals 41.5 mm. or 0.6 mm. more than the 1948 dividing point. The population was low in 1954 but the average weight was normal (3.02 pounds). In contrast, the average weight of muskrats harvested in 1948 was 2.84 pounds.

The marsh conditions at Montezuma were much improved in 1956 but the harvest was still low. The average weight of muskrats increased to 3.23 pounds in 1956 and 3.41 pounds in 1957. The heads of 551 muskrats were obtained in February and March 1957. These were cooked, their zygomatic breadths measured, and their first lower molar teeth examined. These data were treated as were the 1948 data; the results are plotted in Fig. 3. The characteristics of these curves are similar to those in Fig. 2, except for an upward shift of about 1.5 mm. in the point where 25 per cent of the class has the dental characteristic. This places the dividing point at 42.5 mm., which results in 86.2 per cent subadults. A sample of 88 pelts was aged by the pelt-primeness method early in February. These were the government's one-half share and 80.7 per cent were subadults. The skulls of the entire catch (184) for the same period were measured and divided at 42.5 mm., resulting in 78.8 per cent subadults, a similar ratio.

The trapping season opened earlier in 1958 and it was possible to examine 413 pelts from the government's share of the January harvest. Most of these were taken from a portion of the Refuge that had been drained three years

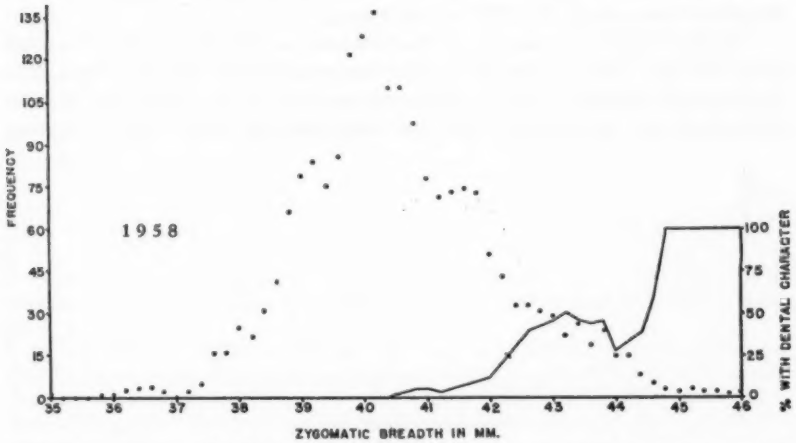

FIG. 4.—Frequency distribution of zygomatic breadth measurements and percentage of each size class possessing the dental characteristic for 672 muskrats in 1958; data smoothed by 3-point moving sums.

earlier. The vegetation had become dense the previous year, followed now by a peak muskrat population. A 400 per cent increase in the number of muskrat houses was recorded for this section of the marsh. Only 25 of the pelts were prime and of the remainder 86.3 per cent were subadults. The heads for the same period were obtained and measured. The unbroken skulls totaled 672 and the first lower molars of all skulls over 40.6 mm. in breadth were examined. The smoothed percentages of those possessing the dental characteristic are plotted in Fig. 4 along with the zygomatic breadths for the 672 skulls. Again, similar characteristics are seen in that the percentage increase is a two-step phenomenon, first stopping at the 50 per cent level and then proceeding to the 100 per cent level. The point where the dental characteristic was observed in 25 per cent of the skulls was 42.3 mm., 0.2 mm. below the 1957 figure. Using this new point, the subadults equaled 86.7 per cent, essentially the same as the 86.3 per cent obtained by the pelt-primeness method. Production on this new marsh area was very high.

Another sample of pelts from the first week in February was aged. Thirty-nine of 274 pelts were prime and the remainder contained 83.8 per cent subadults. The heads of 119 were measured and when divided at 42.3 mm., 84.0 per cent were subadults.

A third sample was taken during the first few days of April. The pelts were prime and could not be aged. Head measurements were taken on 169 muskrats; subadults equaled 72.4 per cent. This drop in subadult percentage can be explained in part by three things: (1) subadults usually decrease in percentage as the season progresses, (2) some growth in the skull of subadults could have occurred in this three-month period, and (3) the behavior pattern of muskrats in April is different from that in midwinter. The average weight of the muskrats for 1958 was 3.28 pounds.

Trapping began on 1 January at the Montezuma Refuge in 1959. The catch from the same areas as studied in 1958 was examined for the first three days, totaling 482 muskrats. The government's one-half of the pelts was 86.6 per cent subadults. Another 697 pelts that were taken between 5 and 18 January

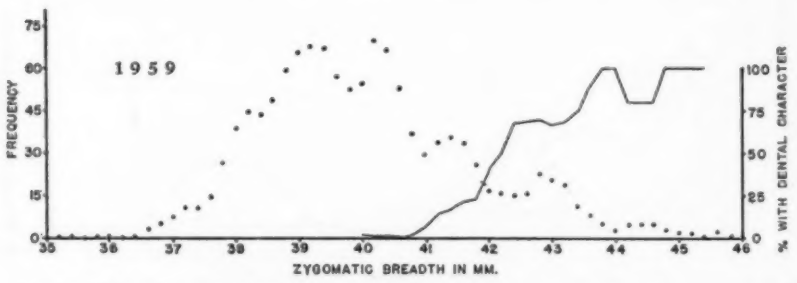

FIG. 5.—Frequency distribution of zygomatic breadth measurements and percentage of each size class possessing the dental characteristic for 424 muskrats in 1959; data smoothed by 3-point moving sums.

were aged as 85.1 per cent subadults. A third sample of 298 pelts was examined at the end of February. Nearly one-half were prime but the remaining 158 contained 82.3 per cent subadults. Production was still very high on this newly developed marsh.

The heads of 424 from the first sample were unbroken and were measured in a fresh condition. The heads were cooked to expose the lower molar. Data on the zygomatic breadth and the percentage of each size class with the dental characteristic were treated the same as for the previous years; the graphs are presented in Fig. 5. The dental characteristic is present in 25 per cent of the 41.9-mm. class. This again is a reduction from the preceding year, this time 0.4 mm. When this point is used for age separation, 86.3 per cent are subadults. This agrees very closely with the 86.6 per cent based on the pelt-primeness method. The average weight of the 1959 muskrat was 3.09 pounds.

Again the two-stage increase in the percentage of lower molars with the first fluting base exposed is seen. The increase is abrupt to about the 50 per cent level, and later to the 100 per cent level.

There appears to be a relationship between the zygomatic breadth dividing point for the two ages and the average weight of the muskrats from the habitat. The data do not permit detailed evaluation of this relationship. However, in general, the two values seem to fluctuate together. The smaller the muskrats, the greater is the rate of skull increase. This relationship might be as follows: (1) skulls of muskrats averaging 2.75–3.00 pounds increase in width by 1/3 mm. for each tenth-pound increase in weight; (2) skulls of muskrats averaging 3.00–3.25 pounds increase in width by 1/4 mm. for each tenth-pound increase in weight; and (3) skulls of muskrats averaging 3.25–3.50 pounds increase in width by 1/6 mm. for each tenth-pound increase in weight. Undoubtedly several other factors enter into this relationship.

The writer appreciates the cooperation given by Refuge Managers Lawrence Smith and John Morse of the Montezuma National Wildlife Refuge in obtaining the muskrat heads used in this study and in permitting the examination of pelts.

SUMMARY

Variation in the size of muskrats from different habitats necessitates the shifting of the dividing point between ages when zygomatic breadth measurements are used for aging purposes.

Characteristics of the first lower molar were found to be helpful in locating the dividing point. The beginning of the adults is indicated when 25 per cent of the zygomatic breadth class contains this molar with the end of its first proximal fluting above the bone line. This feature was studied for four years and the age ratios each year were almost identical to those obtained by the pelt-primeness method.

It was also found that when there was a shift in the dividing point, there was an associated shift in the average weight of the muskrats.

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BEHAVIOR OF A CAPTIVE PACIFIC PILOT WHALE

BY DAVID H. BROWN

On 27 February 1957, a pilot whale, *Globicephala scammonii*, was captured 5 miles off Long Point, Santa Catalina Island, California, by the crew of the collecting vessel "Geronimo" of Marineland of the Pacific. To the best of my knowledge, this was the first pilot whale ever specifically taken for live display. The one that was held for seven months at Marine Studios, Florida (Kritzler, 1952), had been stranded.

After being ensnared by the collecting apparatus, the whale fought for 5½ hours. During this time it was accompanied by five or six other pilot whales which swam slightly ahead, sounding and surfacing to breathe in unison. Several striped dolphins, *Lagenorhynchus obliquidens*, were also observed swimming with the ensnared animal. Similar behavior was observed during the capture of striped dolphins (Brown and Norris, 1956). When the whale was brought alongside the collecting vessel, the striped dolphins remained with it, swimming as close as 5 or 6 feet from the hull of the "Geronimo." The other pilot whales, however, did not venture closer than about 40 feet.

The captured animal proved to be a female, and measured exactly 12 feet from the tip of her snout to the median notch of the tail flukes. On her arrival at Marineland the whale was lowered into a holding tank 30 feet in diameter and 6 feet deep. As soon as released, she attempted to sound, and in so doing struck her snout on the floor of the tank. This was the whale's last effort to submerge while held in this enclosure.

For the next few days she floated on the surface, making soft squealing noises, the sound being almost identical to that made by the bottle-nosed dolphin, *Tursiops truncatus,* at Marineland. Although several kinds of food were offered, including squid, mackerel and live anchovies, the pilot whale refused to accept nourishment. Soon her reluctance to swim resulted in the top of her head, back and dorsal fin becoming severely sunburned—a condition reported by Kritzler (*op. cit.*) on stranded pilot whales. Some relief was rendered by the liberal application of zinc oxide ointment.

It was decided to move the whale to a larger tank. The circular dolphin tank was considered. However, at Marine Studios, Florida, the aggressive behavior displayed by the bottle-nosed dolphin had resulted in the death of a pilot whale. It was therefore decided the whale should be placed in the large fish tank (100 feet long, 50 feet wide, 22 feet deep). Transfer was difficult, owing to the whale's size (Plate I). The tail musculature was injected with 20 cc. of vitamin B_1 and 20 cc. of Metacorten, to act, respectively, as an appetite stimulant and as a tranquilizer.

The whale still refused to submerge, but commenced to cruise slowly around the surface, keeping well clear of the walls. Toward the end of the day, food was again offered but was refused. Following another unsuccessful attempt the next morning, I entered the tank equipped with "Desco" shallow-water diving gear and a pair of 16-inch metal tongs. I swam toward the whale,

PLATE I

A large mattress-padded wooden platform proved useful during the transfer. (Photograph by F. Lowe.)

who demonstrated no great alarm at my approach, and forcibly rammed the tongs between her lips in an effort to make her open her mouth. Several attempts were made before the whale appeared to learn what was expected and, finally, at my approach began to snap her jaws in my direction. This behavior appeared similar to that commonly used as a warning signal by the bottle-nosed dolphin (Essapian, 1953; McBride and Hebb, 1948).

I threaded a quantity of squid onto light nylon line and reentered the tank. On being approached, the animal resumed the warning behavior. Each time this occurred, the squid was thrust into its mouth, only to be regurgitated almost immediately. The whale ponderously tried to evade my efforts to feed her. Except for clapping its jaws, no aggressive behavior was apparent. Eventually a quantity of squid was consumed. No further difficulties were encountered, as the whale greedily accepted the food proffered her. In the ensuing 72 hours, she consumed 210 lbs. of food, most of which was thrown to her from above the surface.

During succeeding days the whale's general behavior markedly improved. She became increasingly more venturesome and began to sound and explore the confines of the tank. It soon became apparent that the animal was adapting itself to captivity far more rapidly than any one of the three species of dolphins already established in the collection.

Just ten days after commencing to feed, she learned to swim to a small wooden platform and raise her head partly above the water, to take food from tongs held in my hand. The whale ate 60 pounds of squid daily, all of which was accepted in this manner.

A large dolphin fish, *Coryphaena hippurus,* living in the tank learned to identify the feeding platform as a source of food and quite often tore squid out of the tongs and sometimes even out of the mouth of the pilot whale. This appeared to infuriate the whale, which on more than one occasion turned with some agility and pursued the fish for a short distance.

Two species of turtles are also kept in this tank, the green turtle, *Chelonia mydas,* and the loggerhead turtle, *Carretta carretta.* Several of these animals would congregate around the feeding platform on the appearance of the attendant, also apparently attracted by the prospect of food. Their presence seemed to annoy the whale, and a number of times she was observed to swim toward a turtle at considerable speed, butting the creature with her head. One morning the author saw a small turtle struck with such force that it was thrown about 3 feet out of the water.

On another occasion a large green turtle was injured quite severely. The impact of the whale's onslaught shattered the anterior parts of the turtle's carapace and plastron.

Competition from other animals during feeding periods soon ceased. The pilot whale learned to stop in an upright position in front of the feeding platform, thrusting her head completely above the water and maintaining the position by a slow movement of her flukes. The whale was slowly induced to

lift a third of her body out of water by holding the food a little higher each day. Success in this effort indicated that a possibility existed of teaching the animal routines comparable to those learned by trained dolphins. It was, therefore, decided to embark on a whale-training program employing techniques identical to those used in the training of sea lions and dolphins.

The whale quickly learned to retrieve a rubber inner tube (18 × 4 in.) and on 11 June 1957 was observed to dive, holding the tube in her mouth. When she surfaced to breathe a few seconds after this, the tube was missing. We believed that the tube was lodged between the rocks, but a thorough search made by members of the Marineland diving staff failed. It was concluded that the whale had swallowed the tube.

The animal's feeding behavior continued quite normal until five days later, when only half of her daily allotment of 60 lbs. was consumed. The whale refused to feed almost completely on 17 June. The following day 100 mg. of aphomorphine were administered orally to induce regurgitation. This was unsuccessful, probably because of the oral administration. On 19 June, Dr. G. Wheat suggested that a large quantity of medical mineral oil might be given orally. Next day, the pilot whale accepted 15 pounds of squid, each with its mantle cavity filled with mineral oil. During the following two days it consumed an additional 90 pounds of oil-filled squid.

In the early morning of 23 June, the tube was found floating on the tank surface. It was quickly removed and was found to be still fully inflated after reposing for 12 days inside the pilot whale, which now resumed her normal feeding behavior.

The tendency of captive cetaceans to swallow foreign material has, in the past, caused several fatalities, both at Marineland of the Pacific and Marine Studios, Florida. In most cases the animal involved ceased to feed, thus eliminating the possibility of administering oral medication.

The mineral-oil treatment, however, has since been used successfully twice on bottle-nosed dolphins. One had swallowed a leather glove, the other a wooden ball. Mineral oil seemingly can be used for cases of this kind with favorable results if the consumption of such objects is suspected.

During the following weeks the attendants readily encouraged the animal to lunge even higher from the water. Then, in order to facilitate the whale's efforts, a modified feeding platform was built that could be mechanically raised over 15 feet above the water.

The animal learned to surface under the platform and, after determining the position of the food held in the attendant's hand, she would sound to the floor of the tank, turn and swim toward the surface with great power. Thus she cleared the surface in a most spectacular manner.

The whale displayed little alarm at being touched, when fed at the surface. This allowed her trainer to teach her a number of routines using a whistle as a "bridging stimulus" and food as a reward.

The first trick the whale learned was "shaking hands." The trainer, grasping

the animal's flipper as she waited at the feeding platform, blew his whistle and then rewarded the whale with a quantity of squid. The whale rapidly learned to anticipate the hand movement and rolled over on her side to present a flipper to the trainer. The sound of the whistle was an invaluable asset in training, acting as a span between the attempted or successful completion of the act and the receipt of the reward. By the same method, the whale learned to retrieve a plastic dumbell as well as several other tricks, one of the most interesting being to "sing."

When given the correct cue by the trainer, the whale clapped her jaws and at the same time forced air through her pursed blowhole, making spasmodic noisy eructations. The rapidity with which she learned was quite remarkable. In a short time she perfected these tricks and many others, thus enabling the public to enjoy her performance at regularly scheduled "show" periods during the day.

The intelligence of certain small odontocetes has been discussed elsewhere (McBride and Hebb, 1947; Essapian, 1953; Brown and Norris, 1956). However, the pilot whale's adaptability to captivity and response to training so soon after capture appear even more remarkable than the behavior of captive bottle-nosed, common and striped dolphins. It is doubtful that the pilot whale is the most intelligent of the four species. However, it certainly appears to be less fearful of human contacts. McBride and Hebb (*op. cit.*) describe the fear reaction of the bottle-nosed dolphin when a strange object is introduced into the tank. Identical reactions were observed in the Marineland tank among the three species of dolphin mentioned above.

When unusual objects were introduced into the whale's tank, the pilot whale registered little or no concern. Once I lowered a large dinghy into the tank and, to my surprise, no fear reaction was registered by the whale. She came to the dinghy's side after a few minutes to be fed and even performed several tricks, receiving her cues from the unusual new feeding platform. This comparative lack of fearfulness may be the reason for the pilot whale's rapid response after such brief exposure to captivity and human contact.

However, the pilot whale is much more difficult to approach at sea than are either the common or striped dolphin, which often play around the bow of our collecting vessel.

A plastic hose 35 feet in length on the surface of the oval tank is used to direct floating detritus into an overflow pipe. The pilot whale sometimes rubbed the entire length of her body on this hose. Between feeding periods she spent hours at this practice, often lunging completely over the hose. On several occasions she became so violent during this play that the device was torn from its mountings and had to be repaired and replaced.

This was the only playful behavior observed during the animal's sojourn in the oval tank. On numerous occasions the whale was also seen poised vertically in the water, head down. In this position the tail flukes were sometimes

smacked down upon the surface of the water with great force. The significance of this behavior is not apparent.

Although the pilot whale was still receiving 60 pounds of squid each day, she became more aggresive in her search for food. During the regular descents of the diver to feed the fishes and turtles, she soon appeared to recognize him as a source of food and anticipated his arrival. It soon became a problem for the diver to distribute the food, as the whale attempted to swallow even the smallest portion of squid or mackerel removed from the food basket, leaving only infrequently to breathe. Certain slow-swimming animals, particularly the rays and turtles, were subjected to some mistreatment upon securing a piece of fish. They were frequently snapped at and butted to such an extent that they disgorged the food. The whale occasionally pursued some of the fishes in the tank, and caught and ate a number of kelp bass, *Paralabrax clathratus*. After the pilot whale had been living in the tank for several months, about 60 Pacific barracuda, *Sphyraena argentea*, were placed in the exhibit. The whale appeared to relish these fish particularly and, gradually over a period of several weeks, almost eliminated the barracuda display.

During the first week of February 1958, the pilot whale again lost her appetite. The animal constantly rubbed its genital opening on the rocks on the floor of its tank, in fact utilized any protuberance available for this purpose. On several occasions, even the diver's helmet was used, much to the man's discomfort. This behavior was observed for approximately two weeks, at the end of which the whale resumed her usual daily pattern. It is possible that her estrus cycle may have occurred at this time. Similar behavior occurs during heat in trained female sea lions. At such times they also lose appetite and rarely respond to the techniques of the trainer.

The pilot whale initially appeared quite tractable in her relationship with the divers and attendants, gently accepting food from either above or below the surface and displaying little concern with diving operations not involving the distribution of food. After about 14 months of captivity, her behavior toward the diver began subtly to change. This first became evident during the underwater feeding periods. The whale normally appeared not unduly displeased at the man's attempts to feed the other occupants of the tank, although always endeavoring to consume the major portion of food carried by the diver. She now began actively to push the diver with her head and snap at his hands if he made an effort to feed the other animals. This aggressive behavior finally was directed sporadically against any diver entering the tank. One man, while swimming on the surface, narrowly escaped serious injury when the pilot whale tried to ram him against the wall of the tank.

On 29 April 1958, two photographers, accompanied by the author and all wearing shallow-water diving gear, entered the tank to photograph the whale. Toward the conclusion of this project the pilot whale became violent and, after knocking one photographer off his feet, approached his colleague and myself, snapping her jaws in a most menacing manner. It was therefore decided to

leave the tank, whereupon the whale directed her ire upon a large camera and tripod left standing on the bottom. She struck this with such force that the heavy metal range finder attached to the camera was badly buckled. Four days after this, on 3 May, a diver conducting a routine feeding was so severely rammed that he lost consciousness briefly and almost drowned. All diving operations in this tank were thereupon suspended.

While aggressive behavior of this nature has not been previously recorded from captive cetaceans, I am informed that at Marine Studios, Florida, a bottle-nosed dolphin kept in solitary confinement for many months became unstable and frequently tried to bite anyone careless enough to place his hand in or near its tank.

The well-developed social behavior of the bottle-nosed dolphin has been well described (McBride and Hebb, 1948; Essapian, 1953), and it appears that enforced solitude of this nature may prove disagreeable to this species. Social behavior in pilot whales is at least as well developed as in smaller species (Fraser, 1949: 305; Kritzler, 1952) and enforced solitude may prove equally disquieting to these larger animals.

In July 1958, the pilot whale was moved into a larger tank, which she shared with two striped dolphins and a smaller female pilot whale recently added to the exhibit. The whale had increased 10 inches in total length since she had been in captivity and, although other comparative measurements were not taken, it was obvious that her girth had greatly increased.

In the new enclosure, at first the smaller animal regarded the larger with great suspicion, and always swam away from the big whale when she moved too close. The small dolphins, however, showed little timidity and, for the first week of their association, spent hours tormenting the larger whale, biting her flukes whenever opportunity arose. This seemingly infuriated the larger animal and resulted in many hot pursuits. The smaller, more agile dolphins always easily evaded the rushes of the pilot whale.

After a month, the whales commenced to swim side by side, and at this writing are often observed playing together. They commonly rub the entire lengths of their bodies against each other. During this play the two often lunge half way out of the water. They also lie together on the surface with their eyes closed. While in this position either animal sometimes produces a series of explosive popping sounds by forcing air through its pursed blowhole.

At 9:45 AM, 17 January 1959, a loud unusual sound was heard from the tank, made by the larger of the two whales as they maintained an almost stationary head-down position. The individual vocalizations lasted for about 3 seconds, during which time a stream of air bubbles could plainly be seen emerging from the blowhole. This was the first time that either whale had been heard to vocalize beneath the surface. The sound was unlike any recorded for *Tursiops* or *Lagenorhynchus* and is best described as similar to the noise made by a device in toy dolls for producing a crying sound. This sound has been heard

once since then. The meanings of this vocalization and the sound produced by the animals while lying on the surface are not apparent.

Since the whale has been moved into the circular tank she has taken no further aggressive action against the divers, conceivably because of the company of the other animals.

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to William E. Schevill and Carl L. Hubbs for their helpful suggestions and criticisms; and also to Mrs. Muriel Johnson for her help in preparing the manuscript. He also wishes to thank Kenneth S. Norris and Captain Frank Brocato, skipper of the "Geronimo," for the observations made during the capture of the pilot whale.

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Contribution No. 7, Marineland of the Pacific Biological Laboratory, Marineland, California. Received 16 March 1959.

CRANIAL VARIATION IN THE NORTH AMERICAN RED FOX

By Charles S. Churcher

Cranial variation of the North American red fox, *Vulpes vulpes* Linn., was studied (Churcher, 1959) to determine the extent to which variation was correlated with age or sex, and the possibility of establishing criteria for age or sex determination.

Materials.—Available were 188 crania of fur-farm red foxes, for which the age and sex were known, and 1,288 crania from wild specimens of which 324 were of known sex. The crania from the fur farms were mostly undamaged, but damage to the braincase, rostrum, zygomata, and the loss of some teeth and mandibles had occurred in several of the wild specimens. Data on locality, sex and date of capture were often either vague or lacking, but the information relating to the fur-farm specimens was complete. The 188 crania of known age and sex, hereafter referred to as the "aged sample," comprised 79 males and 109 females (Table 1). The crania are grouped by sex and year-class. A year-class includes all those individuals of the same age pelted by

TABLE 1.—*Distribution by year-class and sex of the 188 fur-farm specimens of known age and sex*

Year-class:	1	2	3	4	5	6	7	8	9	10	11
Males:	53	7	8	2	2	4	2	1	0	0	0
Females:	40	17	19	13	9	6	2	1	0	1	1

the fur farmer in the same year, and since pelting usually takes place during the first half of December, and the young are usually born at the end of March or the beginning of April, each year-class is some three months short of a full year, i.e., first year-class animals range from 0–9 months, second year-class animals from 10–21 months, etc. Since the date of birth varies over a period of about 15 days, and the pelting period likewise, an error of a month is possible in the recorded age of the specimens. Thus, a first year-class animal may be from 8–10 months of age at pelting, and a second year-class animal from 20–22 months, etc., the second year-class therefore ranging from 8–10 months to 20–22 months.

VARIATION

Twenty-three cranial measurements were taken on each skull of the aged sample and coefficients of variability (CV) were calculated to determine whether the fur-farm animals could be considered as a single population. The CV's were calculated for each dimension in groupings both by age and sex, the values obtained lying between 2.0 and 4.0 in the main, with limits of 1.0 and 8.6. These CV's are somewhat lower than those determined by Simpson and Roe (1939), who found that "for linear dimensions of anatomical elements of mammals . . . the great majority lay between 4 and 10, and that 5 or 6 were good average values." The low values for CV could reflect uniform conditions of food and environment, and possibly selection as to size and shape by the fur farmers. The aged sample was more uniform than a sample from a wild population and consequently variation because of age or sex should be more easily discernible.

Since the dimensions—total length of the skull (TL), width across the mastoid processes (MW), width across the zygomata (ZW), and length of the mandible (ML)—will be used subsequently in this paper, CV's for these four dimensions are given here (Table 2).

Age variation in the aged sample.—Variation because of differing age was present but no age groupings could be obtained on the basis of the dimensions measured. Sullivan and Haugen (1956) radiographed the feet of captive red foxes and found that the radial and ulnar epiphyses fused at approximately 9 months.

Wood (1958), in his study of the gray fox, *Urocyon cinereoargenteus*, concluded that apart from separations into juveniles and adults by examination of the teats, bacula, uteri and epiphyses, tooth wear reflected the cumulative age more than any other char-

TABLE 2.—*Values of CV for the 188 crania in the aged sample*

DIMENSON	CV		
	Both sexes	Male	Female
TL	3.36	2.88	2.72
MW	2.84	2.84	3.36
ZW	3.55	3.43	2.01
ML	3.41	2.82	2.88

acter examined. He also discovered that the fusion of the presphenoid-basisphenoid suture occurred between the tenth and eleventh month and the vomerine-presphenoid gap closed by the 24th month. Conditions in the red fox do not appear to correspond closely to those in the gray fox, since tooth wear was found to be unreliable as an age indicator, and the presence of a vomerine-presphenoid gap was randomly distributed in the year-classes. Fusion of the presphenoid-basisphenoid suture takes place between 10 and 22 months, which approximates the condition reported for the gray fox.

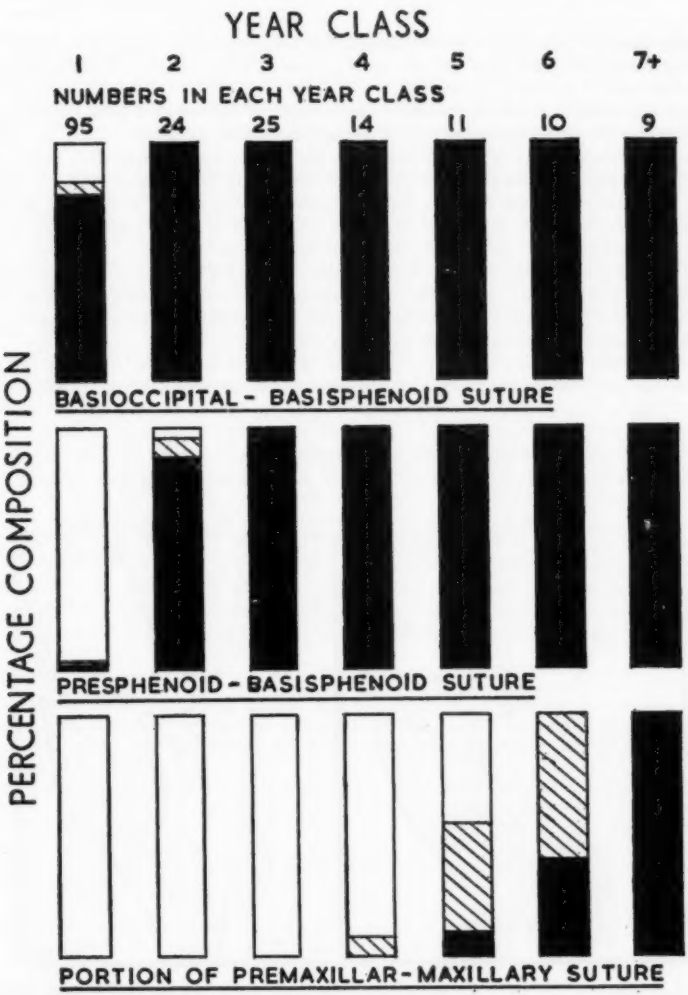

FIG. 1.—Suture closure in the aged sample by year-classes given as percentages of open (white), closing (shaded) and fused (black) sutures. See text for explanation.

TABLE 3.—*Distribution of the shape of the lateral anterior processes of the nasals in 180 specimens of the aged sample; figures indicate the number of specimens falling within the three categories by age class and sex*

Year-class:	1	2	3	4	5	6	7	*Male*	*Female*
Bluntly Rounded	6	9	18	9	7	9	8	22	44
Bluntly Pointed	17	7	8	5	4	1	1	20	23
Pointed	62	9						32	39

Suture closure in the skull was investigated, but only three showed promise. Tooth eruption was investigated and also showed some promise. These results are discussed below. These two sets of criteria allow specimens of unknown age to be assigned comparable ages. A number of additional criteria for separating animals of various ages were developed, and brief mention of other characters which proved unreliable as aging criteria is included.

The three sutures selected as age criteria are the presphenoid-basisphenoid, basioccipital-basisphenoid, and the lateral palatal portion of the premaxillar-maxillary suture lying between the anterior palatine foramen and the lingual margin of the alveolus of the upper canine. Closure of these sutures is shown in Fig. 1. The oldest animals are grouped under the heading "7+," as all three are fused by this age.

Figure 1 shows that the three sutures do not close simultaneously. The basioccipital-basisphenoid suture closes during the first year of life of the animal, the presphenoid-basisphenoid during the first and second year, and the palatal portion of the premaxillar-maxillary suture during the fourth to sixth years of life.

The conditions of the sutures are given by year classes in Fig. 1, each histogram showing the percentage composition of the year-classes as fused, partly fused, and unfused or open for the three selected sutures. The figures at the top of the histogram give the total number in each year-class with the year-class immediately above it.

The basioccipital-basisphenoid suture was fused in the majority of cases in the first year-class and completely fused in all animals in the second year-class or older. The

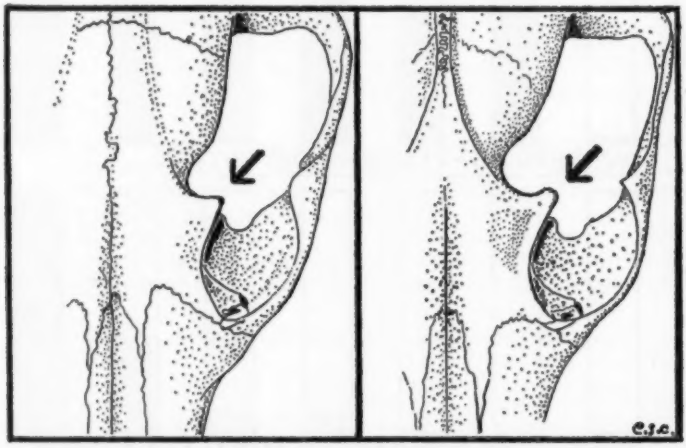

FIG. 2.—Details of the supraorbital region in the skull of the red fox. The arrow indicates the change in shape of the postorbital processes from first year (left) to fourth year (right) animal.

presphenoid-basisphenoid suture was fused in only one first year animal, partly fused in one, and open in the remaining 93. In the second year-class it was fused in 21 out of 24 animals, open in one, and partly fused in two. In all animals beyond this class it was fused.

The palatal portion of the premaxillar-maxillary suture lateral to the anterior foramen was open in all animals in the first three age classes, partly fused in one of 14 fourth year, partly fused in five of 11 fifth year, and partly fused in 6 of 10 sixth year animals. It was fully fused in one fifth year animal, in four sixth year animals and in all nine seventh year and older animals.

Instances of fusion were noted during the examination of the other three cranial sutures. These occurred mainly in animals three years old or greater, but some fusion was noticed in younger animals. The following sutures were found to be fused in a small number of cases: parietal-squamosal, parietal-interparietal, parietal-frontal, frontal-squamosal, frontal-alisphenoid, maxillar-jugal, maxillar-palatine, intermaxillary, interpalatine, lachrymal-jugal, parietal-supraoccipital, pterygoid-palatine, interpremaxillary, rostral portion of premaxillar-maxillary, and sphenoid-squamosal. None of these is of value as an aging criterion because there was no consistency with which fusion occurred.

The width of the postorbital processes showed no variation with age, but a slight tendency existed for the dimension to be greater in males than in females. A change of shape of the processes from triangularly pointed to spatulately rounded occurred (Fig. 2). Of the 188 specimens in the aged sample, 84 out of 119 in the first two year-classes were triangularly pointed and 53 out of 69 more or less spatulate. Intermediate conditions were shown by 32 from the first two year-classes and 15 from the older classes, and one second year-class possessed spatulate processes and one third year-class pointed triangular processes.

Roughening of the temporal areas occurs in some genera of Canidae, e.g., *Urocyon* and *Otocyon*, and may be more marked in some specimens than in others. Roughened areas were noted in only 11 out of 95 specimens in the first year-class but 91 out of 93 in the second and subsequent year-classes had roughened areas. Both specimens with smooth areas from the second group were from the second year-class. Roughened temporal areas can be associated with the second year-class and smooth areas with the first.

Examination of the length of the nasal along the midline of the skull, its width at the base of the rostrum, its shape at the margin of the nares, and the relative position of its posterior margin to that of the posterior supraorbital margin of the maxilla showed no age variation in 50 crania of the aged sample. The shape of the lateral anterior process of the nasal varied from a pointed to a bluntly rounded condition. Table 3 gives the

TABLE 4.—*Key for aging cranial specimens of Vulpes vulpes; abbreviations used as follows:* BOBS—*basioccipital-basisphenoid suture;* PSBS—*presphenoid-basisphenoid suture;* TA—*temporal areas;* ALPN—*anterolateral processes of the nasals;* PC—*pulp cavities of the teeth;* POPS—*postorbital processes;* PMMS—*lateral palatal portion of the premaxillar-maxillary suture*

		Age, Months	*Year-class*
1.	BOBS open	0 – 9	1st
	BOBS closed — 2.		
2.	PSBS open, TA smooth, ALPN pointed, PC large	10–21	2nd
	PSBS closed, TA roughened, ALPN pointed or bluntly pointed, PC reduced — 3.		
3.	POPS triangularly pointed (Fig. 2)	22–33	3rd
	POPS spatulately rounded, ALPN usually bluntly rounded — 4.		
4.	PMMS open	34–57	4th and 5th
	PMMS partly fused or fusing	58–81	6th and 7th
	PMMS fused	82+	8th and older

distribution of the shape of this process as pointed, bluntly pointed and bluntly rounded for 180 specimens of the aged sample, and shows that the pointed condition is confined to the younger animals of the first year-class and that the blunter conditions are commoner in the older year-classes. Intermediate conditions occur in all year-classes, but are less numerous in the older categories.

While the width of the postorbital processes, the roughness of the temporal areas, and the anterolateral processes of the nasals are all subjective criteria, they do offer additional factors useful for checking diagnoses based on the evidence of the cranial sutures. In cases where conflicts occur between the two sets of criteria, the evidence of the subjective criteria should be considered less reliable.

The width and length of the sagittal crest, width of the nuchal crest, wear on the upper carnassial, the condition of the anterior process of the presphenoid, width of the mandibular condyles, basilar ridge and basilar area were also considered for variation with age. None of these dimensions or characters showed any variation correlated with age or sex, although generally males tended to be larger than females and older animals possessed heavier crests and condyles; these features were considered useless as criteria for age or sex determination. No correlation between sex and the shape of the postorbital processes, the roughness of the temporal areas or the shape of the anterolateral process of the nasal was evident.

Radiographs of the upper and lower dentitions of animals from each age class were taken to show the pulp cavities. Changes in the size of these cavities occur with age, but

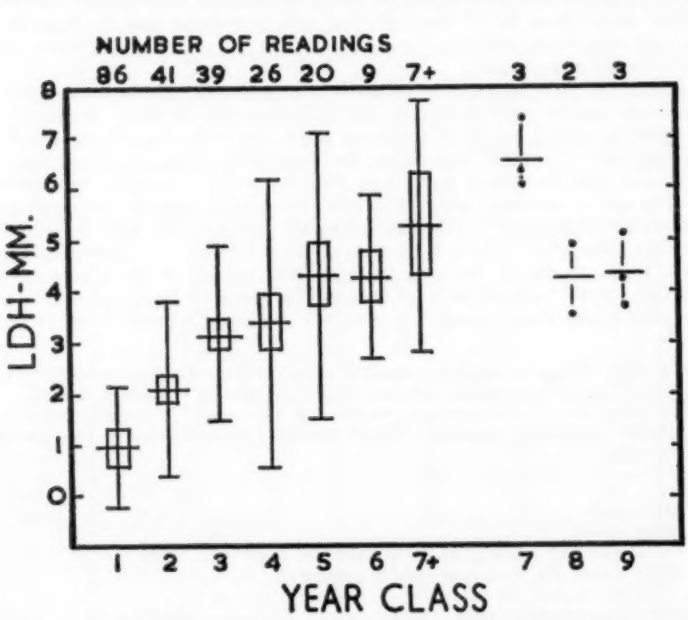

FIG. 3.—Increase in height of C^1 with age as measured by the lingual dentine height (LDH). Means—longer horizontal lines; two standard errors—boxes; and two standard deviations—vertical lines, plotted by year-classes. Measurements in mm.; numbers of readings in each year-class given at top of figure. Column 7+ includes means of 7-, 8- and 9-year-old animals given separately in columns 8, 9 and 10, respectively.

do not show a progressive change correlated with increasing age. An obvious change occurs between first and second year-classes, in which the thin-walled newly erupted tooth loses its large pulp cavity which is reduced to a canal of more or less uniform width. This partial occlusion of the pulp cavity occurs in all the teeth at about this age.

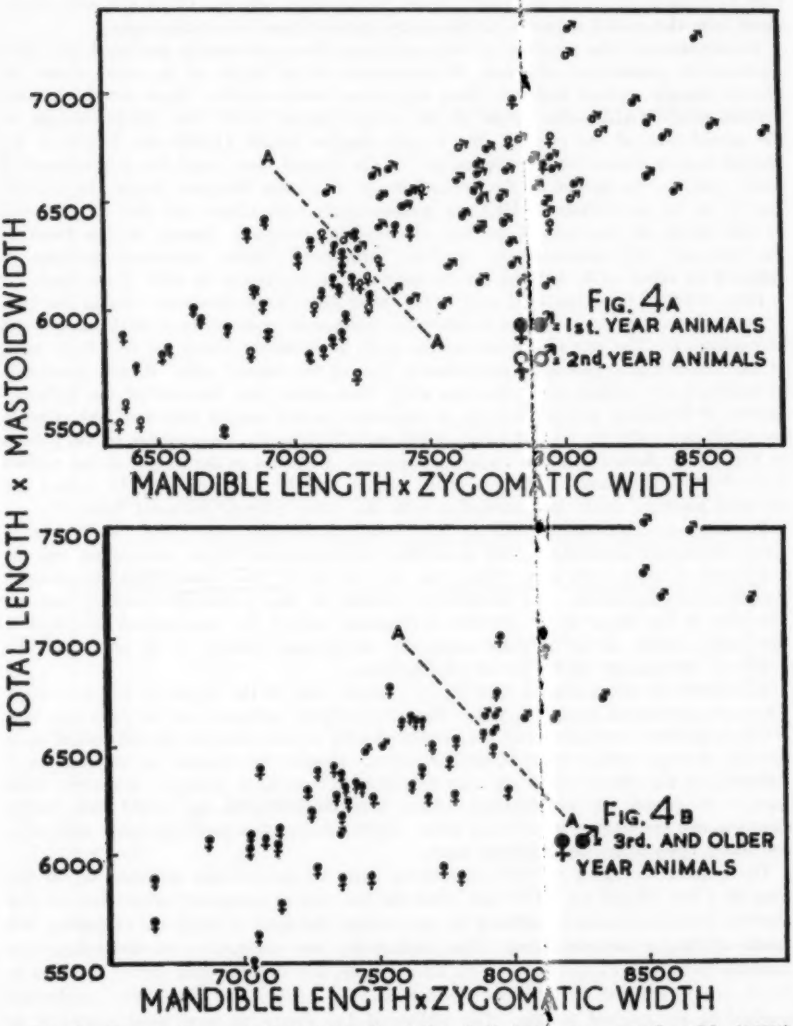

FIG. 4.—Scatter diagrams of total length of the skull (TL) × mastoid width (MW) plotted against zygomatic width (ZW) of the skull × mandible length (ML). Males and females indicated by symbols. 4*a*—first and second year animals; 4*b*—third and subsequent year animals.

This observation offers a means of distinguishing between juvenile and adult animals, but its inconvenience is such as to preclude its general use, as the condition of the presphenoid-basisphenoid and basisphenoid-basioccipital sutures gives the same information at a glance.

Transverse sections of the upper canines of the aged sample showed no progressive change in microscopic anatomy with age of the secondary dentine filling the pulp cavity, apart from the partial occlusion of the cavity apparent from the radiographs.

Investigation of the eruption of the canines in the aged sample indicated that they increased in prominence with age. Measurements of the height of the tooth above the alveolar margin showed that only three dimensions were reliable. These are the anterior dentine height (ADH—the height of the enamel margin above the alveolar margin on the mesial face of the canine), the lingual dentine height (LDH—the height of the enamel margin above the alveolar margin on the lingual face), and the anterior enamel height (AEH—the height of the enamel at its maximum thickness above the alveolar margin on the mesial face). All three measurements were taken with dial calipers read to two places of decimals. Care was exercised to recognize damage to the tooth or the bone and such measurements noted as "estimated." Similar measurements were attempted on other teeth, but the results were not as conclusive as with the canines.

Data obtained from the aged sample for these three dimensions were similar for both upper and lower canines. Figure 3 shows the increase in prominence of LDH of C^1 with increasing age. The rate of eruption of the tooth is maximum during the first three years of the animal's life, becoming progressively less as the animal ages. It was impossible to construct an accurate curve for ages older than seven years because of the high frequency of broken or very worn teeth in which the enamel margin had been lost. Graphs for ADH and AEH for C^1 and LDH, ADH and AEH for C_1 were similar to the pattern in Fig. 3, but shallower in the vertical component. Variation in the height of the canines is a criterion for estimating the age of an animal, but the decision as to the correct age category must be made in conjunction with the other criteria discussed before.

Summary of age variation.—Of the 26 possible qualitative criteria and the 30 quantitative characters investigated, six qualitative characters and three dimensions can be considered to vary with age. These are the closure of the basioccipital-basisphenoid, presphenoid-basisphenoid, and the palatal portion of the premaxillar-maxillary sutures, alteration in the shape of the postorbital processes and of the anterolateral processes of the nasals, texture of the temporal areas, size of the pulp cavities of the teeth, and the height of the canines above the alveolar margins.

All criteria for aging depend upon changes in the body of the animal as it grows older. These are anatomical changes resulting from physiological processes, and as such they cannot be in absolute correlation with the passage of time as these changes are dependent upon the rate of aging within the individual organism. Despite this indirect relationship, some indication of the chronological age may be obtained from these criteria. Moreover, comparison of animals by physiological rather than chronological age could still further eliminate age variation as a source of error. Such a comparison might be more valid than one based upon direct chronological ages.

The criteria for aging unknown specimens may be conveniently summed up in the form of a key (Table 4). The ages given for the various categories in the key are not absolute because of errors introduced by variations in the dates of birth and of pelting, but results of its use are convincing. The original key was constructed on the information available from only 73 specimens of the aged sample, but with the later arrival of an additional 115 specimens, further aged specimens were available to check the conclusions reached on the original sample. The additional 115 specimens were aged according to the key constructed on the original 73 specimens, and the results checked against the information available from the fur farmers. Correct ages were assigned to 101 of the 115 specimens, and of the 14 incorrectly diagnosed, two differed so strongly from the

normal condition for their recorded age that the possibility of an incorrect age identification by the fur farmer must be accepted. With these two specimens deleted, an accuracy of 89.3 per cent or 101 out of 113, is obtained. The other 12 specimens were all aged within two years of their reported ages. This correlation was considered sufficiently high to validate the use of this system.

The prominence of the canines may be used as a further character for aging a skull. The position of a measurement of LDH from the specimen to be aged is found on the graph (Fig. 3), and the most satisfactory age category selected within the age range allowed by

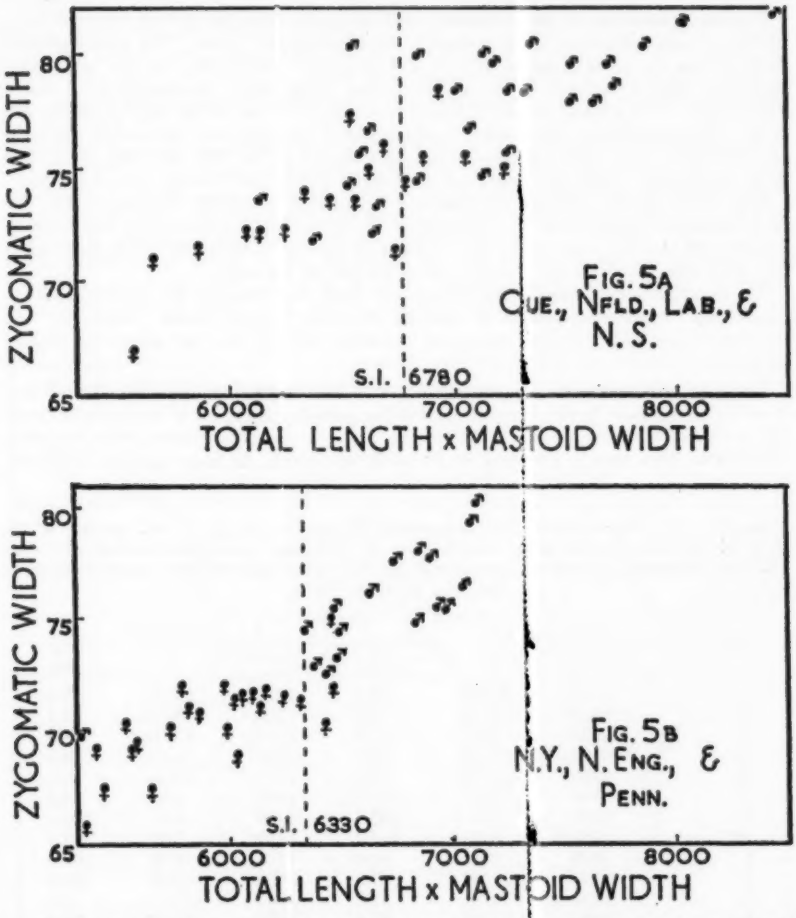

FIG. 5.—Scatter diagrams of total length of skull (TL) × mastoid width (MW) plotted against zygomatic width (ZW). Adult males and females indicated by solid symbols. 5*a*—specimens from Quebec, Newfoundland, Labrador and Nova Scotia; 5*b*—specimens from New York, New England and Pennsylvania.

the key. No discrepancy between the prominence of the canines in animals from eastern and western North America, because of size variation, was found when the system was tested on 100 specimens of wild origin from all over the continent, a correlation of 93 per cent being obtained in the ages assigned from the key and from the eruption of the canines.

Cranial variation due to sex.—When the 23 dimensions measured for the CV's were plotted to show means, range and standard deviation, by sex and age groups, the males tended to be larger than the females in most dimensions. Some characters or dimensions showed a constant size difference between the sexes in all year-groups, while others showed not only a basic size difference but also a progressive increase in the difference with age.

Various combinations of the dimensions measured were tried, the indices obtained being plotted as scatter diagrams, in an attempt to relate dimensions to sex. The most successful of these was TL × MW against ML × ZW (Fig. 4). The scatter for first and second year-class animals appears to be a straight-line relationship approximating a normal distribution. The animals are divisible into two groups by sex at the position of the line A–A. The separation at this position is approximately 91.8 per cent, the sample consisting of 98 specimens, of which 38 females and 52 males lie to the left and right of the line A–A, respectively. Only two males and six females fall on the "wrong" side of the line.

The scatter of the third and subsequent year-classes is essentially the same. The line A–A separates approximately 88.6 per cent of the 61 available specimens by sex, some 44 females and 11 males lying to the left and right of the line, respectively. Only three males and three females fall on the "wrong" side of the line in this case.

The sex of an animal may be determined from these dimensions of the cranium with approximately 90 per cent chance of accuracy for both first-and-second (combined) and third-and-subsequent year-class specimens, providing that the two age groups are treated separately.

Sexing of wild specimens.—As the sex determination is based on a combination of four cranial measurements in the second step, and the animals are known to vary in size across the continent, the effect of this variation was tested on the northeastern North American population. This sample consisted of 86 adult specimens, 45 from Quebec, Labrador,

TABLE 5.—*Separation indices* (SI), *percentage separation* (% sep.), *and number of individuals separating out from the sample* (N), *the numerator giving the number separating while the denominator gives the sample size, for both adult and immature populations from the areas given in Fig. 6*

AREA	ADULTS			IMMATURES		
	SI	N	% Sep.	SI	N	% Sep.
A	6330	18/19	94.7	6000	17/20	85.0
B	6600	13/22	59.1	6400	8/14	57.1
C	6400	5/6	83.3	6200	13/18	72.2
D	6780	18/26	82.3	6500	11/16	68.8
E	6800	14/19	73.7	——	——	——
F	6600	6/7	85.7	6200	5/6	83.3
G	6100	6/6	100.0	6100	3/3	100.0
H*	6400	6/6	100.0	6100	5/6	83.3
I	6600	2/4	50.0	6500	4/4	100.0
J	7050	24/35	75.0	6600	2/2	100.0
K	7000	9/11	81.9	——	——	——
L	7300	14/17	82.4	7000	13/17	76.5
M	7000	2/2	100.0	6600	6/7	85.7
N	6400	25/31	79.6	——	——	——

* SI derived from measurements in Grinnell, Dixon and Linsdale (1937).

Newfoundland and Nova Scotia, and 41 from New England, New York and Pennsylvania. The indices of TL × MW were plotted against the ZW as mandibles were frequently lacking on specimens of *V. v. fulva* and *V. v. rubricosa* (includes *V. v. deletrix* and *V. v. bangsi* [Merriam, 1900]) (Fig. 5).

The vertical lines that give the best separation by sexes will be referred to as the "separation indices" (SI), and will be designated by the value of the abscissa, being 6780 and 6330 for Figs. 5*a* and 5*b*, respectively. The separations at these lines are approximately 70 and 90 per cent, respectively. A marked difference exists between these two lines and it would be most inaccurate to assign a sex to a specimen of *V. v. fulva* from the scatter diagram for *V. v. rubricosa*, and vice versa.

Table 5 shows that SI's reflect the variation in size of the skulls of the adult and immature populations of the North American red fox. The maximum SI is 7300 in Alaska, where the animals possess the largest skulls, and minima of 6330 and 6100 on the Atlantic coastal plain and the West Coast, respectively, reflect populations of the smallest animals. The areas for which SI's were calculated were devised on the basis of the subspecific distribution (Fig. 6).

The wide range in percentages of animals separated into the correct sexes by the indices may be partly due to small sample sizes. This may be rectified when larger samples are available. The percentages separated lie above 70 in most cases. Low percentage separations for samples B and C may be attributed to mixed populations in the Great Lakes area and to immigrants from populations A, I and E.

The possibility of sexing cranial specimens of wild red foxes can be considered as tentatively established. The SI's given in Table 5 were applied during later work carried out on geographic variation in the red fox cranium, and were found quite serviceable.

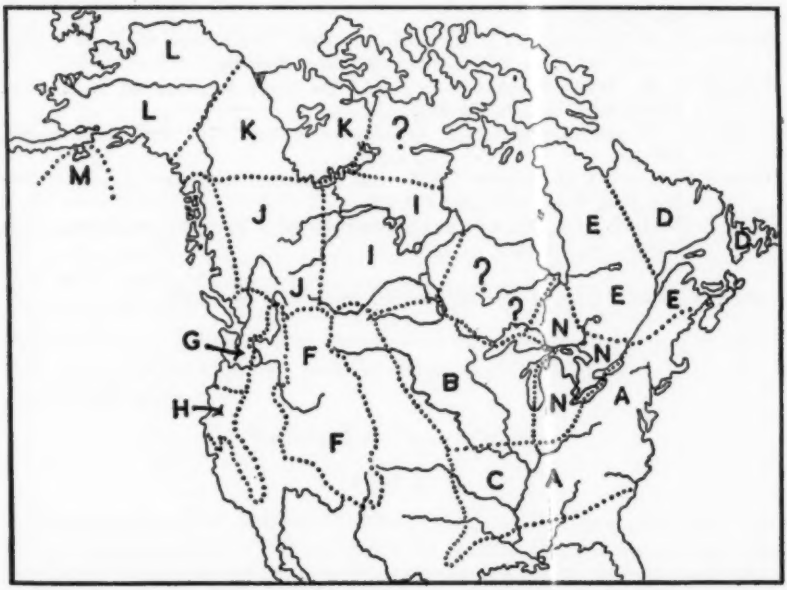

FIG. 6.—Geographical areas for which the separation indices given in Table 5 have been calculated. Question marks indicate areas for which no data are available.

SUMMARY

Variations due to age and sex in 188 red fox skulls of known age and sex were investigated. Age criteria were established on the closure of the cranial sutures, shape of the postorbital processes and of the anterolateral processes of the nasals, the texture of the temporal areas, the size of the pulp cavities of the teeth, and the eruption of the canines. These criteria are summarized in a key for aging an unknown red fox cranium with errors of up to two years.

Sexual variations in the crania can be distinguished, provided the older specimens are considered separately from the first and second year specimens. The sexing of unknown crania is then based on the magnitude of three cranial dimensions: total length, zygomatic width and mastoid width. Mandibular length is useful also but, because of the frequent absence of mandibles, it was omitted. Indices were found for the different North American populations of red foxes by which separation of male and female crania may be effected with varying degrees of accuracy.

ACKNOWLEDGMENTS

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MIDDLE PLEISTOCENE CARNIVORES FROM SOUTHWESTERN KANSAS

By Lowell L. Getz

Remains of carnivores are relatively rare from the Crooked Creek formation (Hibbard, 1949) in Meade County, Kansas. The Atwater member (Hibbard, 1958) of this formation has yielded the Cudahy fauna of late Kansan (glacial) age from below the Pearlette volcanic ash and the Borchers local fauna of Yarmouth (interglacial) age from above the Pearlette ash.

Mustela sp. was reported by Hibbard (1944) from the Cudahy fauna. This record was based on an isolated DP_4. Four genera of carnivores have been reported from the Borchers local fauna (Hibbard, 1941, 1942). These records were based chiefly upon fragmentary jaws or isolated teeth.

The University of Michigan Museum of Paleontology field parties washed approximately 6 tons of fossil-bearing matrix from the Borchers Quarry site in 1952 and approximately 15 tons from the Cudahy faunal sites at localities 10 and 17 in the summer of 1958. They recovered additional specimens and new records of carnivores from those two Pleistocene faunas.

I wish to thank Claude W. Hibbard for permission to report upon these specimens, as well as for assistance in identifications and preparation of the manuscript. W. H. Burt also provided assistance in the identifications. The drawings were made by Michael O. Woodburne and were paid for by the National Science Foundation (Project G–5635).

CUDAHY FAUNA

Canis sp.

An astragalus (No. 38406) belongs to a form the size of a small wolf and is larger than the coyote (*Canis latrans* Say). This specimen was taken from below the Pearlette ash lentil on the Big Springs Ranch, NW ¼, Sec. 18, T. 32 S, R. 28 W, Meade County. The specimen was compared with the astragalus of a yearling Recent *C. lupus* Linnaeus from Michigan. It agreed in size and form with two exceptions. The depression in the neck region is much shallower than in the Recent specimen, and the flange of the fibular articular surface is more prominent.

Mustela cf. **erminea** Linnaeus

(Fig. 1)

Three specimens, an isolated M^1 (No. 38339), an M_1 associated with a portion of the ramus (No. 38338) and a P_4 (No. 38340), also associated with a portion of the ramus, are referable to this species. The occlusal surfaces of these teeth resemble those of both *M. erminea* and *M. rixosa* Bangs. On the basis of size they are referred to *M. erminea*.

The M^1 measures 3.2 mm. along its length and has a width of 1.2 mm. Measurements of the M^1 of 37 specimens (24 ♂♂ and 13 ♀♀) of Recent *M. rixosa* revealed ranges of 2.1 to 2.7 mm. for the length and 0.9 to 1.1 mm. for the width. Similar measurements of 15 specimens (10 ♂♂ and 5 ♀♀) of Recent *M. erminea* revealed ranges of 2.3 to 4.0 mm. for the length and 1.0 to 1.8 mm. for the width. The Cudahy specimen, therefore, clearly falls within the range of *M. erminea*.

The M_1 is referrable either to *M. rixosa* or *M. erminea*. The paraconid is broken, but enough remains to obtain a fairly accurate measurement of the length of the tooth. It measures 3.9 mm. along its length and has a width of 1.3 mm. Measurements of the M_1 of the same Recent specimens indicated above revealed ranges of 3.1 to 4.0 mm. (avg. 3.6 mm.) and 3.6 to 5.4 mm. (avg. 4.2 mm.) for the length of the M_1 of *M. rixosa* and *M. erminea*, respectively. The width ranges were 0.9 to 1.2 mm. and 1.0 to 2.0 mm. for *M. rixosa* and *M. erminea*, respectively. The Cudahy specimen, therefore, more closely approximates the size of *M. erminea*. Since the presence of *M. erminea* is indicated by the assignment of the M^1 to this species, the M_1 is also referred to *M. erminea*.

The portion of the lower jaw associated with the M_1 further supports reference of the specimen to *M. erminea*. Although its size is within the range of both species, it is somewhat larger than the average *M. rixosa*. As *M. erminea* has on the average a larger ramus, the Cudahy specimen more nearly resembles this species.

The P_4, on the basis of size, can be referred either to *M. erminea* or *M. frenata*.. Since the other specimens are referred to *M. erminea* this specimen also is tentatively referred to this species.

Mustela cf. vison Schreber

(Fig. 1)

One specimen (No. 38341), an isolated M_1, is referred to this species. This specimen is in the general size range of *M. vison*, but displays some differences. The heel is slightly wider than in Recent forms. The Cudahy specimen has a ratio of heel width to total length of .333 (width 2.3 mm., length 6.9 mm.) while similar measurements of 40 Recent specimens of *M. vison* (20 ♂♂ and 20 ♀♀) yielded an average of .386 with a range of .350 to .425. The occlusal surface of the heel is slightly different from Recent forms. The heel of the Cudahy specimen slopes from the hypoconid to the inner edge of the tooth while all Recent forms show a distinct cup-shaped depression. Observations on several worn, Recent specimens indicate that this cup-shaped depression is retained even after considerable wear. The peculiar structure of the Cudahy specimen is therefore probably not a result of tooth wear.

On the basis of these differences, it is quite possible that this specimen represents a new form of mink. Since the differences are rather slight and only one specimen is available it does not seem advisable to name it.

The specimens of the weasel and mink were taken in the SW ¼, Sec. 2, T. 31 S, R. 28 W, locality 10, Meade County, Kansas.

BORCHERS FAUNA

Canis cf. latrans Say

(Fig. 1)

Ten specimens (Nos. 33800 and 40225), consisting of isolated teeth or fragments of the lower jaw associated with two or three teeth, are present. All teeth are similar to those of *C. latrans* in size and occlusal surface with the exception of the M_1, which differs only in size. The Borchers specimens of the M_1 (a complete left tooth and a fragment of a right tooth with the heel and hind root missing) are more massive than in the Recent forms. They both have a width (at the level of the protoconid) of 9.0 mm. Measurements of 64 Recent specimens gave an average width of 7.6 mm. with a range of 6.4 to 8.7 mm. The heel of the complete tooth is somewhat wider (8.4 mm.) than the average of the Recent forms (7.9 mm.), but falls within the range of variation (6.7 to 9.3 mm.). The average width of the heel in the Recent forms is greater than the width at the protoconid. In only three of the 64 Recent specimens measured was the width of the heel less than the width at the protoconid. The M_1 of the Borchers specimen thus differs in this respect from Recent forms of *C. latrans*.

Urocyon atwaterensis sp. nov.

(Fig. 1)

Holotype.—UMMP 40223. A right M^2. Collected by Claude W. Hibbard and party, summer of 1952.

Horizon and type locality.—Middle Pleistocene, Crooked Creek formation, Atwater member (above the Pearlette ash lentil), Borchers local fauna (Yarmouth), NE ¼, Sec. 21, T. 33 S, R. 28 W, locality 9, Meade County, Kansas.

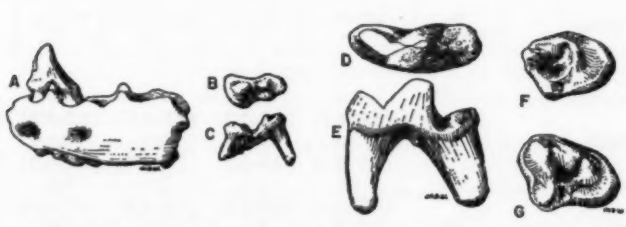

FIG. 1.—A–C, *Mustela erminea*: A, UMMP 38340, left ramus, P_4, labial view, ×3; B and C, UMMP 38339, left M^2, posterior and occlusal views, ×3; D and E, *Mustela vison*, UMMP 38341, left M_1, labial and occlusal views, ×3; F, *Urocyon atwaterensis* sp. nov., UMMP 40223, holotype, right M^2, occlusal view, × 2; G, *Urocyon cinereoargenteus*, UMMZ 89669, right M^2, occlusal view, ×2.

TABLE 1.—*Width to length ratios of the right M^2 of U. atwaterensis and Recent species of foxes*

SPECIES	NO. SPECIMENS	AVERAGE RATIO	RANGE
U. atwaterensis	1	.785	———
U. cinereoargenteus	20	.660	.557–.730
Vulpes fulva	20	.618	.565–.662
V. velox	3	.634	.617–.645
V. macrotis	2	.533	.461–.606

Diagnosis.—A gray fox the approximate size of *U. cinereoargenteus* Schreber. The M^2 has a well-developed cingulum and is wider than Recent forms. A small cusp is present between the protocone and metacone.

Description of the type.—The occlusal surface is rather different from that of *U. cinereoargenteus*. The cingulum extends from the base of the hypocone to a point halfway between the protocone and paracone. The cingulum is also much wider than that of *U. cinereoargenteus*. Comparisons with Recent species of *Vulpes* revealed all to have a much narrower cingulum than *U. atwaterensis*. A small accessory cusp is present in the depression between the protocone and metacone. Examination of all available Recent species of foxes in the mammal collection of the University of Michigan Museum of Zoology indicated this structure to be absent even in unerupted teeth.

The width of the tooth is considerably greater than in Recent species (Table 1). This is mainly a result of the increased width of the cingulum. Measurements of *U. atwaterensis*, not including the cingulum, revealed a ratio of width to length of .699. This is still somewhat larger than the average ratio for the Recent species (in which the cingulum is included). For comparisons of *U. atwaterensis* with *U. cinereoargenteus*, see Fig. 1. Only the holotype is known.

TABLE 2.—*Average measurements (in mm.) of the upper M^1 and lower M_1 of Recent and Borchers specimens of Spilogale; ranges in parentheses*

SPECIES	NO. SPECIMENS	LENGTH M_1	WIDTH M_1	HEEL WIDTH M_1	LENGTH M^1	WIDTH M^1
Borchers specimens	12*	6.6 (5.8–7.1)	2.9 (2.3–3.3)	2.6 (2.2–2.9)	4.7 (4.2–5.2)	2.8 (2.5–3.3)
S. ambarvalis	15	7.0 (5.9–8.1)	3.0 (2.5–3.6)	2.7 (2.2–3.3)	4.9 (4.4–5.9)	3.2 (2.8–4.0)
S. gracilis	20	7.4 (6.7–8.4)	3.2 (2.8–3.7)	2.9 (2.5–3.2)	5.3 (4.7–6.4)	3.4 (3.0–4.2)
S. interrupta	12	7.7 (7.1–8.3)	3.4 (3.2–3.6)	3.1 (2.9–3.2)	5.6 (5.3–6.3)	3.7 (3.3–4.2)
S. putorius	9	7.8 (7.4–8.0)	3.5 (3.2–3.7)	3.2 (3.0–3.5)	5.8 (5.5–6.4)	3.7 (3.4–3.9)

* Only six specimens of M^1.

Mustela cf. **frenata** Lichtenstein

Two specimens are present, a complete M_1 (No. 35772) and a fragment of an M_1 (No. 24785), both associated with portions of the ramus. The complete M_1 measures 4.9 mm. and 1.5 mm. along its length and width, respectively. In size it is closer to *M. frenata* than to *M. erminea*, but falling within the range of both. The jaw rami are slightly more massive than in most *M. erminea*, but still within the range of extra large specimens. The faunal relationships indicate that *M. frenata* is the most likely weasel to be present. The Borchers fauna indicates an interglacial period (Hibbard, 1949) and probably a warm climate. Since *M. erminea* is a more northern form, it is doubtful that the specimens belong to this species.

The fragment is sufficient to allow an estimate of its measurements. It length is approximately 5.1 mm. and its width, 1.8 mm.

Spilogale cf. **ambarvalis** Bangs

Several additional specimens of *Spilogale* are added to the fauna (Nos. 35773, 24784, 40224). Hibbard (1941) assigned the Borchers form to *S. leucoparia* Merriam, now considered synonymous with *S. gracilis*. The additional specimens have made it possible to reassign it to *S. ambarvalis*. The new specimens consist of four isolated M_1 and three M^1 teeth, as well as numerous premolars, canines and incisors. Comparison of all the specimens now available reveals that the Borchers form is considerably smaller than the Recent specimens of *S. gracilis*. They approach *S. ambarvalis* in size, although they also average slightly smaller than this species (Table 2).

The occlusal surfaces cannot be differentiated from any of the Recent species. *S. putorius* (= *interrupta*) occurs in southwestern Kansas today, but the Borchers specimens are distinct from this species. The present-day range of *S. ambarvalis* is restricted to the southeastern portion of the United States.

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NUMBERS AND POPULATION STRUCTURE OF THE PINNIPEDS ON THE CALIFORNIA CHANNEL ISLANDS

By George A. Bartholomew and Richard A. Boolootian

Five genera of pinnipeds (*Eumetopias, Zalophus, Arctocephalus, Phoca* and *Mirounga*) occur on the islands off the coast of California, and a sixth genus (*Callorhinus*) occurs regularly offshore during the winter.

During the nineteenth century the pinniped population of California and Baja California was greatly reduced by commercial hunting (Scammon, 1874) and two species, the northern elephant seal (*Mirounga angustirostris*) and the Guadalupe fur seal (*Arctocephalus philippi townsendi*) were brought to the brink of extinction. Since the cessation of commercial exploitation, and the extension of partial protection by the Mexican government and various U. S. agencies, the pinniped population has increased. Since 1927, censuses of the pinnipeds of southern California have been taken at irregular intervals by the California Division of Fish and Game and by individual investigators.

The present study was undertaken to determine (1) numbers of pinnipeds, (2) seasonal changes in their distribution, and (3) population structure during breeding and nonbreeding seasons.

METHODS

Except for the January 1959 counts of elephant seals and Stellar sea lions on San Nicolas Island, all observations were made from helicopters, which afforded advantages not offered by previously available methods—boat, fixed-wing aircraft, blimp, and ground surveys. We were able to travel at any desired speed and altitude, to follow coastal contours precisely, and to circumnavigate the islands so rapidly that our counts have a minimum of duplication. The shore of each island surveyed was skirted at an altitude of 100 to 500 feet depending on the topography of the coast and the local distribution of the pinnipeds. Except for the January 1959 counts, all numbers reported herein are based on photographs which were made with a K–20 aerial camera using Super XX film. Counts were made by examining contact prints and enlargements of the aerial photographs under a dissecting microscope. This method made it possible to determine the species of each animal (Plate I) and to recognize the adult males of all species except *Phoca vitulina* in which conspicuous sex dimorphism is lacking. We did not attempt to differentiate between the females and the immature males in any species, but the pups were tabulated separately. Our counts include each individual animal hauled out on shore or swimming in the immediately adjacent waters and, therefore, represent a minimum size for the various populations.

The elephant seal populations on San Nicolas Island were visited twice during January 1959, and harem structure and time of pupping were determined by direct observation.

RESULTS

Censuses were made of the pinniped populations of San Nicolas, Santa Barbara, Anacapa, Santa Cruz, Santa Rosa and San Miguel Islands during winter, spring and summer. These data are summarized in Table 1.

Mirounga angustirostris.—The spectacular history of this species is well known and has been reviewed by Bartholomew and Hubbs (1952). The species became virtually extinct during the nineteenth century because of commercial hunting, but has since experienced a dramatic recovery. It originally occupied almost 1,000 miles of the Pacific coast of North America from Magdalena Bay, Baja California to a point somewhat north of San Francisco Bay. In 1892, at the low point in its population size, the species was reduced to fewer than 100 individuals and occurred only on Guadalupe Island. Since then, the growth of the population has approximated the familiar logistic curve (see Fig. 1, Bartholomew and Hubbs, 1952). As the population has increased the species has reoccupied parts of its previous range, including the islands off the coast of California.

Prior to the present study, the largest number of elephant seals reported from the Channel Islands was 168 seen on San Nicolas in April 1950 (Bartholomew, 1951). The Channel Island population has continued to increase and now includes at least 412 individuals and perhaps as many as 683 (Table 2). Substantial populations exist on San Nicolas, Santa Barbara and San Miguel (Table 1), and transient individuals are commonly reported from the other islands and adjacent waters. We found the elephant seal breeding on San Nicolas and San Miguel.

During the breeding season (December-February) reproductive activities produce a characteristic organization on the rookeries (Bartholomew, 1952). The breeding unit consists of a dominant bull, a compact group of cows with their pups and a number of subordinate males scattered irregularly about the cows. Seven such breeding groups were seen on the broad beaches at the west end of San Miguel on 14 February 1958 (Plate I). This represents the most northern extension of the present breeding range of the species. During our visits in January 1959, three separate breeding groups of elephant seals were observed on the south side of San Nicolas Island.

The ratios of the various classes in some of the breeding aggregations on San Nicolas and San Miguel are shown in Table 3. For comparison, data based on a much larger sample previously obtained from the much more crowded rookeries on Guadalupe and San Benito Islands are included. It will be noted that the males on the California Channel Islands have much larger harems than those on the Mexican Islands. This is undoubtedly due to the extreme crowding characteristic of the latter rookeries. When congestion on the rookeries becomes acute, the harem structure tends to break down (Bartholomew, 1952: 424).

It has been reported earlier (Bartholomew and Hubbs, 1952; Bartholomew, 1951, 1952) that the number of elephant seals on shore varies markedly with the

TABLE 1.—*Pinniped censuses on the California Channel Islands during 1958–1959*

ISLANDS	SPECIES	DATE	ADULT MALES	FEMALES AND/OR IMM. MALES	PUPS	TOTAL NOT INCLUDING PUPS
San Nicolas	*Eumetopias*	16 Apr. 1958	0	0	0	0
	jubata	9 June 1958	0	0	0	0
		12 Jan. 1959	0	6	0	6
	Zalophus	16 Apr. 1958	544	3,671	0	4,215
	californianus	9 June 1958	348	3,183	281	3,531
	Phoca	16 Apr. 1958	—	21	0	21
	vitulina	9 June 1958	—	34	0	34
	Mirounga	16 Apr. 1958	4	203	0	207
	angustirostris	9 June 1958	8	33	0	41
		23 Jan. 1959	22	90	48	112
Anacapa	*Eumetopias*	14 Feb. 1958	0	0	0	0
	jubata	11 June 1958	0	0	0	0
	Zalophus	14 Feb. 1958	4	17	0	21
	californianus	11 June 1958	0	28	0	28
	Phoca	14 Feb. 1958	—	0	0	0
	vitulina	11 June 1958	—	0	0	0
	Mirounga	14 Feb. 1958	0	0	0	0
	angustirostris	11 June 1958	0	3	0	3
Santa Barbara	*Eumetopias*	16 Apr. 1958	0	0	0	0
	jubata	9 June 1958	0	0	0	0
	Zalophus	16 Apr. 1958	18	516	0	534
	californianus	9 June 1958	40	1,574	2	1,614
	Phoca	16 Apr. 1958	—	0	0	0
	vitulina	9 June 1958	—	0	0	0
	Mirounga	16 Apr. 1958	0	101	0	101
	angustirostris	9 June 1958	1	39	0	40
Santa Cruz	*Eumetopias*	14 Feb. 1958	0	0	0	0
	jubata	11 June 1958	3	0	0	3
	Zalophus	14 Feb. 1958	8	43	0	51
	californianus	11 June 1958	24	113	0	137
	Phoca	14 Feb. 1958	0	0	0	0
	vitulina	11 June 1958	—	16	0	16
	Mirounga	14 Feb. 1958	0	0	0	0
	angustirostris	11 June 1958	0	0	0	0
Santa Rosa	*Eumetopias*	14 Feb. 1958	0	0	0	0
	jubata	11 June 1958	2	15	0	17
	Zalophus	14 Feb. 1958	3	151	0	154
	californianus	11 June 1958	1	72	0	73
	Phoca	14 Feb. 1958	—	54	1	54
	vitulina	11 June 1958	—	0	0	0
	Mirounga	14 Feb. 1958	0	0	0	0
	angustirostris	11 June 1958	0	0	0	0
San Miguel	*Eumetopias*	14 Feb. 1958	0	22	0	22
	jubata	11 June 1958	9	25	3	34
	Zalophus	14 Feb. 1958	1,351	3,299	0	4,650
	californianus	11 June 1958	849	7,160	170	8,009
	Phoca	14 Feb. 1958	—	20	1	20
	vitulina	11 June 1958	—	15	0	15
	Mirounga	14 Feb. 1958	69	306	80	375
	angustirostris	11 June 1958	11	317	0	328

season, and to a lesser extent with time of day. On San Miguel, San Nicolas and Santa Barbara Islands the spring and winter populations were larger than the summer populations (Table 1).

Phoca vitulina.—The populations of harbor seals in southern California are near the southern limit of the range of the species in the eastern Pacific (Scheffer, 1958). *Phoca v. richardi* ranges from Herschel Island, 69° N, to

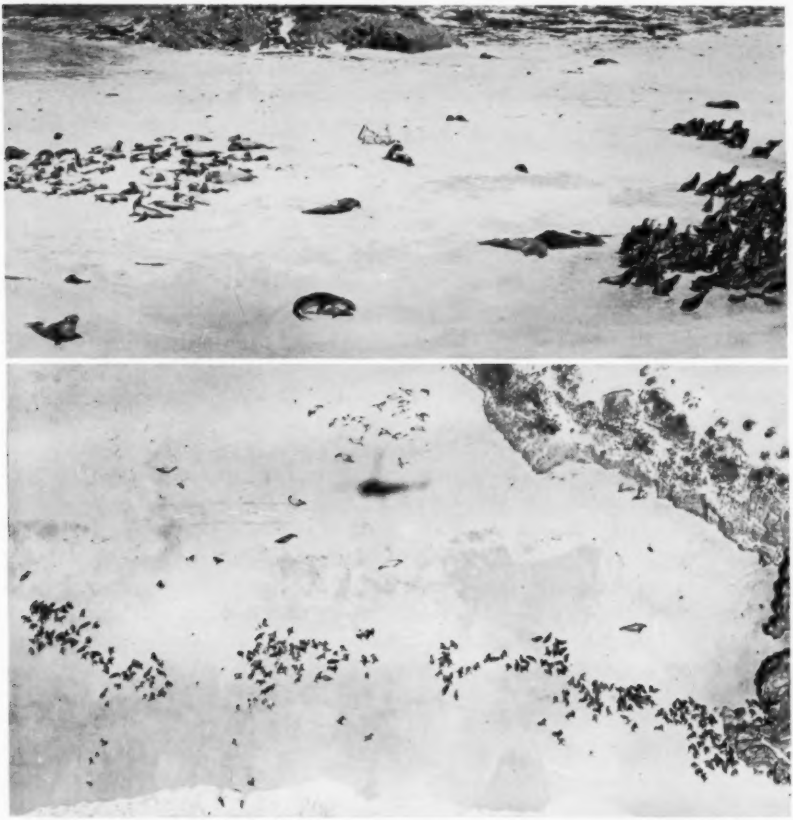

PLATE I

ABOVE: Elephant seals and sea lions as seen from an altitude of 50 feet. Note the subordinate male elephant seal copulating with a female that has left the breeding aggregation shown at left. The group at right shows a preponderance of adult male California sea lions.

BELOW: California sea lions and northern elephant seals on San Miguel Island. In top center just above the shadow of the helicopter is a typical breeding aggregation of elephant seals consisting of cows, pups and a dominant male. Note the subordinate males in a rough half circle about the harem. This picture was taken from an altitude of 500 feet and is typical of the photographs from which our censuses were made.

TABLE 2.—*Total numbers of pinnipeds (pups excluded) on San Nicolas, Santa Barbara, Anacapa, Santa Cruz, Santa Rosa, and San Miguel Islands during 1958. Because of scheduling problems, two visits were required to complete the first census. We have therefore combined the April and February data. The number of individuals shifting from one island to another between our visits, and thus counted twice in the first census, cannot be determined*

	Feb. 14–Apr. 16	June 9–11
Eumetopias	22	54
Zalophus	9625	13392
Phoca	95	65
Mirounga	683	412

northern Baja California, 28° N. The harbor seal is a common inhabitant of the coastal waters of southern California, but its hauling grounds are locally restricted and the herds are small. Furthermore, harbor seals are less approachable than the other pinnipeds of California and take to the water at the first sign of disturbance. Because of our method of census, however, we were able to photograph the herds before they disappeared into the sea. We found *Phoca* on all the islands visited except Anacapa and Santa Barbara (Table 1). The location of the hauling grounds was the same on each visit. On San Nicolas they were on the same sites which they had occupied in 1949 and 1950 (Bartholomew, 1951). Our data (Table 2) indicate that the total shore population on the islands studied approximated 100, which is considerably smaller than the total found on San Nicolas alone in 1949–50.

Eumetopias jubata.—Steller sea lions breed as far north as Herschel Island (69° N) and as far south as the California Channel Islands (33° N) where they occur in the same rookeries with the California sea lions (*Zalophus californianus*). The number of Steller sea lions in southern California is now very small. No adult males were seen during the winter and spring observations, but in June we found two bulls on Santa Rosa, three on Santa Cruz, and nine on San Miguel. The animals on San Miguel were breeding; three newborn pups were seen and a rudimentary harem organization existed. Steller sea lions have been reported as breeding on Santa Rosa (Bonnot, 1951), but we saw no newborn pups there.

The Steller Sea Lion has a remarkably great latitudinal range, over most of which the breeding season appears to be constant. For example, on the Pribilof Islands (57° N) they breed in late May and early June (Osgood, Preble and Parker, 1915: 120; Scheffer, 1945) which is the same as the breeding period in southern California.

The absence of adult bulls in the winter and the presence of either young males or females all year around suggests seasonal migratory movements which may be correlated with age and sex.

Zalophus californianus.—Members of the genus *Zalophus* occur in three disjunct populations, one in the Sea of Japan, one on the west coast of North America, and one in the Galapagos Islands. Scheffer (1958) assigns each of

the three populations subspecific status within the species *californianus*. The population considered in the present paper comes from the north-central part of the breeding range of *Z. c. californianus*.

California sea lions are the most conspicuous and abundant pinniped in the coastal waters of southern California. We observed them on every island on every trip. The principal hauling grounds of this species in the area studied are on the south and west sides of San Nicolas, on all sides of Santa Barbara, and on the extreme west end of San Miguel. The populations of the principal rookeries vary seasonally. On San Nicolas during the spring the population exceeded that during the breeding season, while on Santa Barbara and San Miguel the populations during the breeding season were much larger than those during the winter (Table 1). A comparison of the breeding and nonbreeding populations can be made by pooling the February and April counts and comparing the combined total with the June census. The nonbreeding population in 1958 was between 9,000 and 10,000; the breeding population (not including pups) was slightly more than 13,000 (Table 2).

On the basis of unexpectedly large winter populations of *Zalophus* in southern California, Fry (1939) suggested that there was a winter migration of sea lions from Mexican to Californian waters. Bartholomew and Hubbs (1952) reported that on the San Benito Islands (off Baja California) which support the largest known single population of *Z. c. californianus*, there were virtually no adult bulls during the winter. The present observations revealed that in winter the population of bulls in the California Channel Islands was greater than in the summer; conversely, the summer population of cows exceeded the winter population. These data are consistent with the hypothesis that many bulls move north in the winter and south in the summer while many of the cows and possibly the immature males move south during the winter and north during the summer. This theory is further supported by the fact that on some beaches on San Nicolas and San Miguel the winter sea lion population consisted almost exclusively of adult males. Similar herds of males have been reported south of Monterey (Bartholomew and Hubbs, *op. cit.*) and Cowan and Guiguet (1956) report the regular winter occurrences of *Zalophus* (sex not specified) in the vicinity of Vancouver Island, British Columbia.

TABLE 3.—*Population structure in breeding aggregations of elephant seals*

TYPE	SAN MIGUEL IS., 14 FEB. 1958				SAN NICOLAS IS. 10 JAN. 1959	TOTALS FOR SAN MIGUEL AND SAN NICOLAS	GUADALUPE AND SAN BENITO ISLANDS (Bartholomew, 1952:418)
	Group A	Group B	Group C	Group D			
Subordinate males	14	8	5	5	7	39	115
Dominant males	2	2	1	1	1	7	22
Adult females	36	49	22	17	40	164	290
Ratios:							
Dom. ♂ : Ad. ♀	1:18	1:25	1:22	1:17	1:40	1:23.4	1:13.2
Dom. ♂ : Sub. ♂	1:7	1:4	1:5	1:5	1:7	1:5.6	1:5.2
Total ♂ : Ad. ♀	1:2.3	1:4.9	1:3.7	1:2.8	1:5	1:3.6	1:2.1

Our summer census was taken before the peak of the breeding season, but pupping was well underway. Like other otariids the California sea lion is polygynous, but no intensive studies have yet been made on its breeding behavior. Our photographs allow an interpretation of the breeding structure on at least some rookeries and make possible an estimate of the ratio of breeding bulls to cows. Apparently polygyny in this species is less highly organized and less rigid than in the Alaska fur seal (*Callorhinus ursinus*). If it is assumed that (1) all the bulls on the rookeries during the breeding season maintain harems, and (2) all the other seals (excluding pups) are breeding cows, one can estimate the harem size by a comparison of number of bulls to cows. The ratio of bulls to cows in June 1958 (Table 2) was 1,262 to 12,130—a ratio of nearly 1 bull to 10 cows.

From our photographs we found eight breeding groups showing clearly delineated harem organization and no signs of disturbance due to the presence of the helicopter. The ratio of bulls to cows in these eight harems ranges from 1:12 to 1:18 with a mean of 1:14.

Enhydra and Arctocephalus.—Both the sea otter (Allanson, 1955) and the Guadalupe fur seal (Bartholomew, 1950) have been reported from the California Channel Islands in recent years. During the present observations neither species was seen.

DISCUSSION

During the 30-year period for which data are available there have been conspicuous changes in the total pinniped population of the Channel Islands and in the relative number of the various species (Fig. 1). These changes have been so great that they cannot be attributed to inaccurate sampling or to differences in method of sampling. They can be summarized as follows:

1. The numbers of *Zalophus* have increased logarithmically.
2. The population of *Eumetopias* peaked at about 2,000 in 1938, has declined precipitously since, and now consists of approximately 50 animals.
3. A few *Mirounga* appeared in the late 1930's and the number has increased in the intervening years. There are now over 400 elephant seals breeding on at least two of the islands, San Nicolas and San Miguel.
4. The data on *Phoca* are extremely fragmentary, but the numbers of this species remain relatively small.

It is clear that during the past 20 years *Eumetopias* has been almost completely replaced by *Zalophus* (Fig. 1). Although the ultimate causes for this replacement can never be determined, some information can be adduced to assist in its understanding. Where their ranges overlap in the Channel Islands and along the central California coast, *Eumetopias* and *Zalophus* occupy similar hauling grounds and often form mixed aggregations. In recent years the populations of *Zalophus c. californianus* in the north-central parts of its range have increased markedly. This increase may have been caused by an influx of animals from the enormous populations in Mexican waters. For example, in 1950

there were more *Zalophus* in the San Benito Islands alone than in the entire state of California; moreover, the structure of the San Benitos' population indicated a state of rapid growth (Bartholomew and Hubbs, 1952). By pressure of numbers the California sea lion could so fully occupy the restricted number of rookeries favored by the Steller sea lions that the latter might move elsewhere.

The Steller sea lion is a subarctic to cool temperate species while the California sea lion is a subtropic to temperate species. San Miguel, Santa Rosa and Santa Cruz Islands are the extreme southern limit of the breeding range of the Steller sea lion, but are far inside the northern limit of the breeding range of the California sea lion. Since 1955 the temperature of the coastal waters of California has increased significantly (Calif. Coop. Oceanic Fish. Invest., Progress report, 1956–58: 7–56). This change in temperature may have favored directly or indirectly a northward retreat of the most southerly population of the Steller sea lion and a northward spread of the California sea lion.

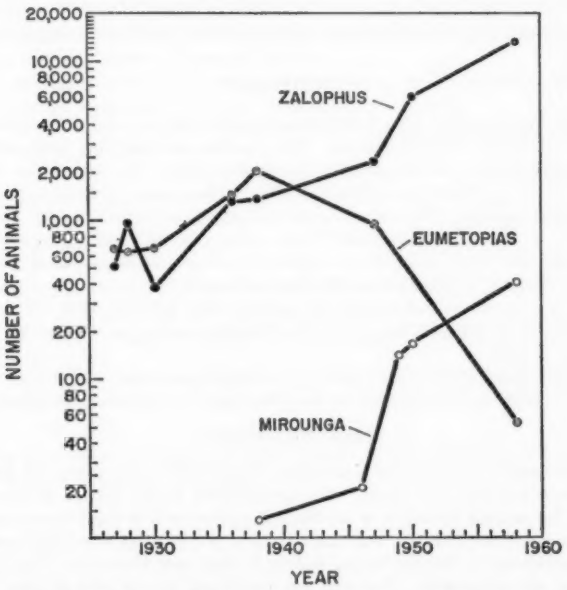

FIG. 1.—Summary of the known history of the populations of three species of pinnipeds on San Nicolas, Anacapa, Santa Barbara, Santa Rosa, Santa Cruz, and San Miguel Islands, showing the replacement of *Eumetopias* by *Zalophus* and the increase in the population of *Mirounga*. All figures are from spring and summer censuses. The data for the sea lions for 1947 and earlier have been calculated from Bonnot and Ripley (1948: Table 1). The *Zalophus* census in 1950 includes only San Nicolas and San Barbara Islands and is based on Bartholomew (1951) and Bartholomew, Collyer and Dawson (1951). The sources of data for the figures on *Mirounga* are as follows: 1938, Loye Miller, personal communication; 1946, Fitch and Wilson (1949); 1949–1950, Bartholomew (1951).

The two sea lions have somewhat different food preferences. Bonnot (1928: 23) found that *Eumetopias* subsisted primarily on fish while *Zalophus* depended primarily on squid. It is well established (Hubbs, 1948) that shifts in the distribution of fish on the Pacific coast of North America can be correlated with periodic changes in the water temperature. A change in temperature as great as that in recent years markedly affects the distribution of neritic forms such as those on which sea lions characteristically feed. The replacement of *Eumetopias* by *Zalophus* in the Channel Islands may, therefore, have resulted from the changes in distribution of critical food species of fish and invertebrates which are relatively sensitive to changes in water temperature. Such temperature-induced changes in local distribution of food species could affect the two species of sea lions differentially.

Present data do not allow a decision as to the relative merits of the various hypotheses outlined above.

The successful breeding of elephant seals seen in February 1958 on San Miguel and January 1959 on San Nicolas shows that they are well established as a breeding population in the California Channel Islands. There is every reason to expect that the elephant seal population on these islands will continue to grow.

SUMMARY

During the last 30 years there have been conspicuous changes in the pinniped population of the California Channel Islands. The numbers of *Zalophus californianus* have increased logarithmically and are now in excess of 13,000. The population of *Eumetopias jubata* peaked at approximately 2,000 in 1938, but has since declined and presently consists of about 50 animals. *Mirounga angustirostris* appeared in the late 1930's and a breeding population in excess of 400 is now established. The population of *Phoca vitulina* has been relatively small and stable and does not appear to exceed 100 at the present time.

Male and female *Zalophus* show different patterns of seasonal movements; the males apparently move north in the winter and south in the summer while the females do the opposite. The mean ratio of male to female *Zalophus* on the breeding rookeries appears to be about one to ten.

The possible effects of crowding, changes in water temperature, and shifts in the distribution of food species on the replacement of *Eumetopias* by *Zalophus* are discussed.

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POPULATION DYNAMICS OF THE HAWAIIAN MONK SEAL

By Dale W. Rice

From October 1957 through July 1958, I was able to make intensive observations on Hawaiian monk seals, *Monachus schauinslandi*, throughout their entire range. More data on population dynamics are now available than when an earlier paper (Kenyon and Rice, 1959) was completed.

FIELD WORK

During the course of the present study, aerial surveys were made of all the islands in the Leeward Chain and landings were made on all but two of the six atolls where seals breed.

Both aerial counts and ground counts were made to determine the present size of the monk seal population. Aerial counts were made from Navy UF-1 Grumman Albatross amphibians flying at about 220 km. per hour at altitudes of 6 to 150 m. Ground counts were made by walking the beaches of the larger islands and by landing on, or closely approaching by small boat, the smaller sandspits.

The dates during which field work was conducted at each atoll are listed below:

Kure Atoll.—I landed on Green Island, Kure Atoll, on 9 May 1958, between 0845 and 1630, and closely observed all the sandspits west of Green Island from an outboard motorboat. Four aerial surveys were conducted at Kure, on 18 December 1957, and 14 April, 2 May, and 28 June 1958.

Midway Atoll.—The most intensive field work was conducted at Midway, where I was stationed from 17 November 1956 through 18 May 1958, and from 12 June 1958 through 21 July 1958, except for a few brief absences. Observations on seals were made several times weekly throughout this period. Since October 1957, eight aerial surveys were made at Midway, on 14 October, 18 and 28 December 1957, and 24 January, 14 April, 2 May, 16 and 28 June 1958.

Pearl and Hermes Reef.—I made six aerial surveys at Pearl and Hermes Reef during the course of this study. These were conducted on 14 October and 18 December 1957, and 24 January, 14 April, 2 May, and 16 June 1958. No landing was attempted.

Lisianski Island.—I made two aerial surveys of Lisianski Island, one on 28 December 1957, the second on 28 June 1958.

Laysan Island.—I spent the period 27 May to 4 June 1958 on Laysan Island. In addition, aerial surveys were conducted on 28 December 1957 and 28 June 1958.

French Frigate Shoals.—I made two aerial surveys of French Frigate Shoals on 28 and 30 December 1957, and went ashore on Tern Island on 26 May 1958; on several of the other islets in the atoll, a count of seals was made from a whaleboat or from the bridge of the cutter *Matagorda*. Additional data on

seals at this atoll were supplied by the U. S. Coast Guard personnel stationed there.

Other areas.—Although monk seals straggle as far as the island of Hawaii, I never observed them either in the main islands or any of the other Leeward Islands. There is one record of two seals seen at Maro Reef (Bailey, 1952). None was seen during three low-altitude aerial surveys of this reef on 28 and 30 December 1957, and 28 June 1958. This extensive shallow reef appears to offer unsatisfactory hauling grounds; it is unlikely that it would be used as a pupping area because of the lack of sandy islets and spits, and the fact that even the highest rocks are awash only at low tide. At Nihoa Island, I saw no seals on 28 December 1957. Seals have not been reported here since 1857 and the exposed nature of the one tiny stretch of beach on this precipitous rocky island makes it improbable that seals ever bred here.

RESULTS

Population size.—The highest counts of adult and subadult seals made at each atoll during the study period are presented in Table 1. The total count for the species' entire range was 1,037. The relation of the count to the true population is difficult to estimate as the number of seals hauled out where they can be counted varies with season, time of day, and perhaps weather. The entire population at a given atoll is perhaps never ashore at one time. However, under favorable conditions, counts at each atoll approach a fairly consistent maximum, suggesting that most of the seals are hauled out. The counts, therefore, are not appreciably below the actual populations. However, a large proportion of the yearling class was doubtless missed (see *Age groups*). Including 169 pups born this season, the minimum number of Hawaiian monk seals alive in the spring and early summer of 1958 was 1,206 (Table 1). To estimate the total population, I have assumed that the entire yearling class was missed during the counts and have, therefore, added 150. Doubtless a few yearlings were seen, but the error introduced by their inclusion will tend to be counterbalanced by adults missed. On this basis, I estimate the present Hawaiian monk seal population at approximately 1,350.

All of the following calculations are based on actual counts of adult and subadult seals at each atoll and are thus subject to the same inaccuracies as these counts. However, the data are comparable *inter se*, so that the conclusions drawn from them remain valid.

Movements.—The accuracy of the census depends to a certain extent on the validity of the assumption that the seals are localized and that there is no appreciable movement between atolls. During 1957, 59 monk seals were tagged on three atolls as follows: Kure Atoll, 16; Midway Atoll, 18; Laysan Island, 25. Among 20 tagged seals examined at these atolls during the following year, I found none which had moved from one atoll to another.

TABLE 1.—*Counts of Hawaiian monk seals in the spring of 1958*

ATOLL	ADULTS AND SUBADULTS	PUPS	TOTAL
Kure Atoll	117	25	142
Midway Atoll	68	8	76
Pearl and Hermes Reef	286	52	338
Lisianski Island	247	34	281
Laysan Island	280	46	326
French Frigate Shoals	39	4	43
TOTALS	1,037	169	1,206

TABLE 2.—*Movements of tagged Hawaiian monk seals in Midway Atoll, 1958 (repeat observations of unweaned pups excluded)*

TAG NUMBER	AGE	SEX	TAGGED*		OBSERVED		DISTANCE FROM LAST PREVIOUS OBSERVATION, KM.
			Date	Locality	Date	Locality	
MS- 3	yrl.	♂	5 Mar. 57	Seal Island	22 Mar. 58	Seal Island	0.02
MS- 4	yrl.	♀	27 Mar. 57	Seal Island*	20 Apr. 58	Seal Island	0.03
MS- 9	pup	♂	11 Oct. 57	Dynamite Island*	22 Mar. 58	middle sandspit	0.20
MS-10	pup	♂	26 Aug. 57	Eastern Island*	22 Mar. 58	Seal Island	2.50
					27 Apr. 58	west sandspit	0.80
MS-34	ad.	♀	12 Nov. 57	Eastern Island	7 Jan. 58	Eastern Island	2.00
					20 Apr. 58	Seal Island	3.60
MS-38	pup	♂	3 Apr. 58	Eastern Island	11 Jul. 58	Eastern Island	0.50
MS-39	pup	♀	9 Apr. 58	Eastern Island	12 May 58	Eastern Island	0.10
MS-40	pup	♀	20 Apr. 58	Dynamite Island	1 Jul. 58	Eastern Island	1.10
					3 Jul. 58	Eastern Island	1.00
MS-41	pup	♀	26 Apr. 58	Dynamite Island	3 Jul. 58	Eastern Island	1.10
					18 Jul. 58	Eastern Island	0.50
MS-42	pup	♀	20 Apr. 58	middle sandspit	11 May 58	east sandspit	0.10
MS-43	pup	♂	20 Apr. 58	middle sandspit	1 Jul. 58	Eastern Island	1.30
					11 Jul. 58	Eastern Island	0.50
					18 Jul. 58†	Eastern Island	1.50
					18 Jul. 58‡	Eastern Island	2.00

* Or date and locality of last previous observation; see Kenyon and Rice (1959).
† 1,255 hours.
‡ 1,402 hours.

TABLE 3.—*Calculated population densities of the Hawaiian monk seal*

ATOLL	AREA OF SHOAL WATER (hectares)	SEAL POPULATION (winter 1957–58)	SEALS PER 100 HECTARES	HECTARES PER SEAL
Kure Atoll	6,200	117	1.89	53
Midway Atoll	8,800	68	0.77	130
Pearl and Hermes Reef	46,000	286	0.62	161
Lisianski Island (incl. Neva Shoal)	16,000	247	1.54	65
Laysan Island	2,600	280	10.77	9
French Frigate Shoals	50,000	39	0.08	1,282

Eighteen repeat observations of tagged seals at Midway Atoll, made since the previous report, confirm the fact that many of these animals may be found in the same general vicinity at intervals over considerable periods of time (Table 2).

Since the completion of the earlier paper, 70 additional seals have been tagged, including 58 at Laysan (No. MS-76 through MS-133) and 12 at Midway (MS-33 through MS-44).

Population density.—The concept of population density is difficult to apply to a littoral marine mammal whose wanderings at sea remain virtually unknown. Nevertheless, by applying available information, some tentative conclusions are indicated, which may throw light on the population dynamics of these animals.

Two observations suggest that monk seals do most of their feeding in the lagoons and on the shoals, rather than over the deep sea: (1) They are apparently quite sedentary and do not normally migrate. (2) From the few stomachs examined, they appear to be bottom-feeders which feed on coral-reef and shallow-water cephalopods and fish (Kenyon and Rice, 1959). The contents of a third seal stomach, found spewed on the beach of Seal Island, Midway Atoll, on 20 April, further confirmed these feedings predilections. It contained approximately 500 cc. of food items, identified as follows: 60 per cent (by volume), one goatfish, *Parupeneus* sp.; 40 per cent, one percomorph fish (Labridae or Sparidae).

The deepest water in which I observed monk seals was 29 m. (16 fathoms); this was one kilometer beyond the reef at French Frigate Shoals.

For calculating population densities, I have measured, on U. S. Coast and Geodetic Survey Hydrographic Charts, the water area within the 18.3 meter (10 fathom) contour at each atoll (Table 3). This represents the approximate limits of shoal water at each atoll. The reef platforms upon which the atolls are formed are quite flat-topped, and drop steeply to ocean depths of about 4,500 meters (2,500 fathoms). By using a deeper contour, the calculations of area would be only slightly larger.

On the above basis, calculated population densities varied from 0.08 to 10.77 seals per 100 ha., or 9 to 1,282 ha. per seal (Table 3).

Reproductive rate.—The total number of pups counted at each atoll in the spring of 1958 is presented in Table 1. Because of the extended pupping season, it is not possible to get

TABLE 4.—*Counts of Hawaiian monk seal pups, Spring 1958*

ATOLL	PUPS COUNTED, April	NEW PUPS COUNTED		TOTAL PUPS COUNTED, Spring 1958
		May	June	
Kure Atoll	10	12	3	25
Midway Atoll	8	0	0	8
Pearl and Hermes Reef	9	28	15	52
Lisianski Island	—	—	34	34
Laysan Island	—	46	0	46
French Frigate Shoals	—	4	—	4

TABLE 5.—*Summary of monk seal pups born at Midway Atoll, 1958*

	BIRTH DATE	SEX	LOCALITY	REMARKS
1.	23 Oct. (est.)	♀	Eastern Island	Aborted fetus found 30 Oct.; length 54.5 cm., weight 3 kg.
2.	early Feb.	?	Seal Island	Aborted fetus reported; length "ca. 18 in." Bones found 11 May.
3.	early Feb.	?	Seal Island	Aborted fetus reported; length "ca. 18 in."
4.	14 Mar.	?	Seal Island	Stillborn, full term; collected 22 Mar.
5.	28 Mar.	♀	Eastern Island	Stillborn, full term; collected 29 Mar.
6.	31 Mar.	?	Rocky Island	Died ca. 11 Apr.; found dead 22 Apr.
7.	2 Apr.	♂	Eastern Island	Tagged MS-38; successfully weaned; last seen 11 July.
8.	8 Apr.	♀	Eastern Island	Tagged MS-39; successfully weaned; last seen 12 May.
9.	10 Apr.	♂	middle sandspit	Tagged MS-43; successfully weaned; last seen 18 July.
10.	15 Apr.	♀	Dynamite Island	Tagged MS-40; successfully weaned; last seen 3 July.
11.	16 Apr.	♀	middle sandspit	Tagged MS-42; successfully weaned; last seen 11 May.
12.	17 Apr.	♂	middle sandspit	Tagged MS-44; last seen 10 May with mother.
13.	24 Apr.	♀	Dynamite Island	Tagged MS-41; successfully weaned; last seen 18 July.

a complete count at one time; the earlier pups are weaned before the later pups are born. Although an occasional pup is born as early as December or as late as June, the majority are born between mid-March and mid-May. Three counts, made during the first half of April, May and June, should result in essentially complete counts. Since the nursing period in this species lasts about 35 days, I have assumed that any nursing pup, observed at least 35 days after the previous count, has been born since that count. Because nursing females and pups are quite stationary, I have also assumed that any nursing pup observed at a locality where none was seen on a previous count has been born since that count, regardless of the time interval. On the first count at each atoll, all pups, including weaned animals, were counted. On subsequent counts only nursing pups were counted, and they were included in the seasonal totals only when they were judged, on the basis of the above criteria, to have been born since the previous count. The results of individual counts at each atoll are presented in Table 4. These are in most cases a combination of both aerial and ground counts. They are believed to be nearly complete, except at Lisianski Island, where only one aerial survey could be made in late June, at which time most pups are weaned, with the resulting possibility of a number being missed. A total of 169 pups were counted throughout the range of the species this season.

The most complete data on the pupping season were obtained at Midway Atoll. There were 13 known pregnancies during the 1957–58 season (Table 5), resulting in three premature abortions, two full-term stillbirths, and eight successful live births. Of the eight live births, one pup died on or before the age of eleven days; its body, when found twelve days later, had a fractured skull which, however, might have been inflicted after death. Six of the remaining seven pups were successfully weaned, the other one probably so. The high rate of stillbirths at Midway may perhaps be attributed to the detonation of explosives during dredging operations in the ship channel, which passes close to the favorite hauling grounds of the seals. No dead pups were found at any of the other atolls, except at Laysan, where the mummified remains of one premature pup were found on the beach.

Reproductive rates, expressed as the number of live pups born per 100 adults and subadults, varied at each atoll from 10.3 to 21.4 per cent (Table 6). The birth rate for the population as a whole was 16.3 per cent, appreciably higher than that reported in 1957 on the basis of fewer data.

These reproductive rates do not help us to understand whether females breed annually or biennially. Even at atolls with high reproductive rates, the number of pups did not equal one-half the adult female population (see *Sex ratios* and *Age groups*). Female monk seals with pups invariably repulse adult males (in some seals, the females copulate while still nursing). These two facts might be interpreted as circumstantial evidence in favor of the theory of biennial breeding. However, there seem to be no biological reasons why a female monk seal should not breed in successive years. Female monk seals fast throughout the nursing period; it is possible that physiological exhaustion resulting from nursing a pup

TABLE 6.—*Calculated annual mortality, natality, and net increment of Hawaiian monk seal populations*

ATOLL	POPULATION		APPARENT MORTALITY		NATALITY SPRING 1958		APPARENT NET INCREMENT	
	spring 1957*	winter 1957–58	number	per cent	number	per cent	number	per cent
Kure Atoll	128	117	11	8.6	25	21.4	14	10.9
Midway Atoll	71	68	3	4.2	8	11.8	5	7.0
Pearl and Hermes Reef	290	286	4	1.4	52	18.2	48	16.6
Lisianski Island	256	247	9	3.5	34	13.7	25	9.8
Laysan Island	233	280	—	—	46	16.4	—	—
French Frigate Shoals	35	39	—	—	4	10.3	—	—

* Data from Kenyon and Rice (1959).

TABLE 7.—*Weights and measurements of newborn Hawaiian monk seals, Midway Atoll*

DATE 1958	SEX	AGE	WEIGHT, kg.	LENGTH, cm.	GIRTH, cm.	"DEGREE OF FATNESS" (girth/length)
28 Mar.	♀	Died at birth	15.2	97.9	45.5	46.5
2 Apr.	♂	4–19 hrs.	18.6	99.0	60.0	60.6
9 Apr.	♀	11.0–12.5 hrs.	19.3	106.0	63.0	59.4

inhibits pregnancy during the succeeding season. The occurrence and significance of nursing-period fasting in the Phocidae requires much more investigation. It has been proved to occur only in *Monachus schauinslandi* and *Leptonychotes weddelli;* the latter breeds annually (Mansfield, 1958). In bearded seals, *Erignathus barbatus,* pregnancies do not occur in succeeding years (McLaren, 1958). In all other phocids, as far as is known, the ovarian cycle is annual (Laws, 1956). It is of interest to note that *Erignathus* and *Monachus* have a number of traits in common (Scheffer, 1958), traits which are possibly primitive phocid (or pinniped) characteristics.

Sex ratios.—The sex of 55 monk seal pups was determined during the present study period. Among nine pups at Midway Atoll were three males and six females. Among 46 pups at Laysan Island were 26 males and 20 females. Combined with data from the previous season, we have a total of 51 males and 49 females. No important new data have been obtained on adult and subadult sex ratios.

Growth rates and age groups.—Weights and measurements of three newborn monk seal pups were obtained this season (Table 7). Some evidence on growth rates was obtained by observations on two seals tagged a year ago as yearlings at Midway Atoll:

MS-3, a male tagged as a yearling on 5 March 1957, weighed 46.3 kg. and measured 129 cm. in total length, tip of nose to tip of tail. On 22 March 1958, his weight was visually estimated at 90–115 kg., and his length at 170–180 cm.

MS-4, a female tagged as a yearling on 5 March 1957, weighed 41.7 kg. and measured 130 cm. in total length. On 20 April 1958, her weight was visually estimated at approximately 80 kg., and her length was measured with a steel tape, as she lay sleeping on the sand, at 150 cm.

From the above data, it appears that growth can be quite rapid, but that there is considerable individual variation in this respect.

As stated in the earlier paper, it is not possible to distinguish age groups, other than pups, with any certainty during aerial counts. However, I was able to make ground counts of the age-group composition of the seal populations at Kure Atoll and at Laysan Island (Table 8). No satisfactory age-group count could be obtained at Midway this season. Monk seals are readily segregated into four size groups: pups, yearlings, subadults (all animals two years old and older which have not attained adult size), and adults. Comparing the 1957 with the 1958 totals, there is not more than 2 per cent difference in the proportion of any age group to the total population.

TABLE 8.—*Age-group composition of two populations of Hawaiian monk seals, 1958*

AGE GROUP	KURE ATOLL		LAYSAN ISLAND		TOTAL	
	number	per cent	number	per cent	number	per cent
Adults	107	76	210	65	317	68
Subadults	8	6	53	16	61	13
Yearlings	2	2	17	5	19	4
Pups	22	16	46	14	68	15
TOTALS	139	100	326	100	465	100

These age-group counts of seals cannot be taken as an indication of the actual proportion of each age group in the population. Rather, they are an indication of the number of seals hauled out on land at a given time. They do, however, bring out two facts: (1) The group classed as "subadults" averages almost as large as, and in some cases is larger than, the pup class. It is extremely unlikely that all the subadults were counted, and it is also inconceivable that no mortality occurs between weaning and the age of two years. Both of these factors would reduce the real or apparent size of this age group. Therefore, it must be concluded that the "subadult" group consists not only of the two-year age group but must also include at least some of the three-year (and older?) age group. (2) The few yearling seals in these counts indicate that they spend much less time on land than do older animals. This is also apparent from the rates of repeat observations of tagged animals (Table 9); the repeat rate for yearlings (i. e., animals tagged as pups the previous year) is only half (12 per cent) that for subadults and adults combined (24 per cent).

In addition to pups and yearlings, a two-year, a three-year, and an adult (four-year-plus) age class may prove to be distinguishable on the basis of average size, although there will be considerable overlap in extreme measurements. It is apparent that monk seals grow more slowly than their Antarctic relatives, the Weddell seals, *Leptonychotes weddelli*, and the crabeater seals, *Lobodon carcinophagus*, which attain adult body size in one year (Bertram, 1940).

TABLE 9.—*Repeat observations of tagged Hawaiian monk seals at Kure Atoll, Midway Atoll, and Laysan Island*

AGE GROUP (age when tagged)	NO. TAGGED, 1957	OBSERVED, 1958	
		number	per cent
Adults and subadults	10	2	20
Yearlings	7	2	29
Subtotal	17	4	24
Pups	42	5	12
TOTAL	59	9	15

Mortality rates.—Mortality rates in adult monk seals appear to be low. Only one dead adult was found during the 1957–58 season—a skeleton in the scrub at the upper edge of the beach on Laysan Island.

An adult seal on Laysan had one hind flipper completely missing, the stump healed. Sharks are the only animals in Hawaiian waters known to be capable of preying on seals. Two species of medium-sized sharks were frequently encountered in the shallow waters close inshore at Laysan. One was a species of "sand shark," *Carcharhinus* sp.; the other was the white-tipped shark, *Triaenodon obesus*, also common at Midway and Kure. Both these sharks seemed to ignore the numerous seals, even the tame newly weaned pups. During June and July, many large tiger sharks, *Galeocerdo cuvieri*, up to four meters in length, entered the shallow lagoons at Kure, Midway, and Pearl and Hermes Reef, apparently attracted by large numbers of fledgling albatrosses (*Diomedea immutabilis* and *D. nigripes*). From the air, I observed them in extremely shallow water only a few meters offshore from beaches and sandspits occupied by seal pups, and swimming in close proximity to seals. There is no evidence that they ever attempt to molest the seals. Hammerhead sharks, *Sphyrna lewini*, are sometimes seen inside the lagoon at Midway. In the deeper waters just outside the reef at French Frigate Shoals, where I observed two seals, there was a large pelagic shark, apparently the mako, *Isurus glaucus*. Any of these larger species are physically capable of attacking monk seals but they must do so only rarely, because the seal population has increased in the presence of a large shark population.

It is interesting to compare the 1957–58 count of adult and subadult seals with the total population count at the close of the previous pupping season (Table 6). Excluding the data from Laysan Island and French Frigate Shoals as not comparable, the apparent mortality rate varied (by atoll) from 1.4 to 8.6 per cent, with a mean of 3.6 per cent. The mean birth rate at the four atolls was 16.6 per cent, representing a net annual increment of 12.3 per cent.

DISCUSSION

An examination of the above data reveals that there is no correlation between population density and reproductive rate, mortality rate, or the net annual increment. These data, together with the historical evidence, indicate that the population is increasing and is not at present limited by density-dependent factors.

It is easy to see how population density may eventually limit further population increase by raising the juvenile mortality rate. The length of the nursing period is determined by the fat stores of the mother, who fasts throughout this period. Weaning apparently takes place when the mother is no longer able to produce milk. The ability of a seal to accumulate fat stores can logically be related to the energy expenditure necessary to obtain a given quantity of food. In more densely populated waters which are "overfished," a pregnant female might be unable to put on much weight prior to parturition. The pups of thinner females are weaned at a younger age and smaller size than are pups of fatter females. They thus have less chance for survival during the critical period following weaning, before they have learned to find their own food efficiently. One pup weaned at an unusually early age at Midway Atoll in the spring of 1957 was not subsequently observed, whereas two of three other pups weaned at a normal age during the same season were known to have survived their first year.

The amount of bottom-living fish and cephalopods on the shallow sandy shoals and coral reefs may be the factor which will eventually limit population growth of the Hawaiian monk seal. Future observations on population size, condition of newly parturient females, length of nursing period, weight of pups at weaning, and mortality of weaned pups, will be necessary to prove or disprove this hypothesis.

SUMMARY

1. In the summer of 1958, the total population of Hawaiian monk seals, *Monachus schauinslandi*, was estimated at 1,350, based on a count of 1,206 (1,037 adults and 169 pups).

2. Eighteen repeat observations of 11 marked seals were made at points 3.6 km. or less from the tagging site.

3. Monk seals seem to feed in shallow waters within the 18-m. depth contour. On this basis, calculated population densities varied from 0.08 to 10.77 seals per 100 ha. of shoal water.

4. Reproductive rates varied from 10.3 to 21.4 live births per 100 adults and subadults. At Midway Atoll, where the seals are subject to human disturbance, 13 known pregnancies in a population of 68 seals resulted in eight live births. Present evidence favors the theory of biennial, as opposed to annual, breeding.

5. Of 100 monk seal pups (including 45 previously reported), 51 were males, 49 females.

6. A two-year-old male and a two-year-old female, tagged a year previously, doubled in weight (46 to ca. 100 kg., and 41 to ca. 80 kg.) and increased in length by 36 per cent and 15 per cent (129 to ca. 175 cm., and 130 to 150 cm.). Apparently most monk seals do not attain full growth until at least four years of age. Age-group classification counts on two populations revealed 14 per cent pups, 5 per cent yearlings, 13 per cent subadults, and 68 per cent adults.

7. Adult mortality is apparently low. Several species of sharks are common, but they seem to pay little attention to seals.

8. The population is increasing and does not now appear to be near the carrying capacity of the range. The size will perhaps be limited eventually by the food supply, which will limit the amount of fat which pregnant females can put on. This will shorten the nursing period of their pups, reducing the pups' chances for survival.

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BREEDING OF MAMMALS IN RAJASTHAN DESERT, INDIA

By Ishwar Prakash

During a project on the "Study of Vertebrates of Rajasthan Desert," sponsored and financed by UNESCO, 500 mammals of 38 species and subspecies were collected (Prakash, 1958*a*). Breeding records, based on field observations and study of gravid females, were available for only 19 species. It appears that there is no common breeding season for all these desert mammals, but that most of them breed just after the rainy season.

OBSERVATIONS

Insectivora.—Young long-eared hedgehogs, *Hemiechinus auritus collaris,* are born from July to September, mostly during the last two months. In captivity, two females gave birth to two and four young each in August; others were dug up with two young each. Observations on parturition in this species are published elsewhere (Prakash, 1955). There have been contradictory statements on the size of the litter. For example, McCann (1937) wrote that it bore only one young. The present observations indicate that a litter varies from one to four. A female Indian hedgehog, *Paraechinus m. micropus,* gave birth to a single young. Another adult was dug out in August with two young. They appeared to be less than a week old, since their eyes were still closed; it was not until a month later that they were able to roll.

Chiroptera.—Flying foxes, *Pteropus g. giganteus,* were observed in May carrying one young each. The young then appeared to be about 15 days old. A few rat-tailed bats, *Rhinopoma kinneari,* bore one young each in August; many young, 15 to 30 days old, were collected in early September. Twelve female lesser rat-tailed bats, *Rhinopoma h. hardwickei,* were collected on 15 May; each contained an early embryo which would probably have been born in June. Three others gave birth in July. Six gravid tomb bats, *Taphozous p. perforatus,* were collected in April; nearly all had delivered by 7 May. Ten false vampires, *Megaderma l. lyra,* carried one fetus each on 4 April; field observations later confirmed that deliveries occurred in May. One female greater yellow bat, *Scotophilus heathi belangeri,* was collected in late August with a 7–15-day-old young on its breast.

Primates.—The rhesus monkey, *Macaca mulatta,* breeds twice a year; young are born in March-May and in September-October. In all, about 72 births have been observed in three troops (Prakash, 1958*b*). About 15 female langurs, *Presbytis e. entellus,* had one young each with them on 10 October. Another female was observed on 21 February carrying a newborn baby; 22 other cases were noted on 10 and 20 March.

Pholidota.—A live pangolin, *Manis crassicaudata,* was captured in November by a villager, who aspired to keep it as a pet. During the night it bore a single young. Feeling pity for it, the villager set it free, and it retreated holding the

baby carefully between its jaws. Heretofore, the mother has been reported (Hopwood, 1929) as carrying its young over the rump or tail.

Carnivora.—In February a red fox, *Vulpes vulpes pusilla,* was dug out of its burrow, which contained three 15-day-old young. They probably had been born in January.

Artiodactyla.—In a reserve near Jodhpur a family of wild boars, *Sus scrofa cristatus,* was observed during October; the mother was accompanied by eight young, apparently about two months old. Newborn calves of black buck, *Antilope cervicapra rajputanae,* and gazelle, *Gazella gazella bennetti,* were observed in August and September.

Rodentia.—Ten gravid five-striped squirrels, *Funambulus pennanti,* each carried three fetuses in May and June. The gestation period is 42 days in this species. Banerji (1957) reported a pet specimen breeding throughout the year at Allahabad, in non-desert country. Most house rats, *Rattus rattus rufescens,* bear their young in May and some in June. Burrows of the Indian gerbil, *Tatera indica indica,* excavated during this study revealed young during September-October and January-February. Litters consisted of five to eight young; this was confirmed by examination of nine gravid females. The desert gerbil, *Meriones hurrianae,* bears its young from September to November. Thirteen gravid females contained from three to five embryos.

DISCUSSION

As summarized in Table 1, there appears to be no common breeding season for all the mammals of Rajasthan desert, although breeding of each species is cyclic. Some mammals breed in all months except December. The primates and the Indian gerbil are the only ones which breed twice a year.

The annual rainfall at three stations in the Indian desert (Pramanik and Hariharan, 1952) is as follows: Barmer, 10.37; Jodhpur, 14.21; and Phalodi, 8.88 inches. Over half of this precipitation occurs during July and August. The number of species breeding increases from January to August and then declines to none in December. The period of maximum breeding corresponds with that of maximum precipitation. This may be correlated with the maximum abundance of food, since all seeds germinate, insect larvae hatch, and birds lay eggs at this season. This agrees with the statement of Bodenheimer (1954), who remarks on the birth data published by Flower: "He showed that the monthly birth incidence of gazelles in the Cairo zoo remained for many years in full agreement with the seasonal rain cycles of their native regions, the peak of the births usually following that of the rains by one month."

On the contrary, Wade (1958) concludes that the onset of breeding is correlated with the period of minimum precipitation, in the lowland rain-forest of North Borneo. There conditions are unfavorable during the rainy season because of excessive rain; hence the mammals breed during the period of minimum precipitation. In the desert, however, the reverse is true. Optimum

TABLE 1.—*Monthly breeding activity in the Rajasthan desert*

SPECIES	TOTAL ♀♀ OBSERVED	NO. OF LITTERS; ESTIMATED MONTH OF BIRTH											
		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hemiechinus auritus	9	—	—	—	—	—	—	1	5	3	—	—	—
Paraechinus micropus	3	—	—	—	—	—	—	—	3	—	—	—	—
Pteropus giganteus	7	—	—	—	7	—	—	—	—	—	—	—	—
Rhinopoma kinneari	5	—	—	—	—	—	—	—	5	—	—	—	—
Rhinopoma hardwickei	15	—	—	—	—	—	12	3	—	—	—	—	—
Taphozous perforatus	6	—	—	—	—	6	—	—	—	—	—	—	—
Megaderma lyra	10	—	—	—	—	10	—	—	—	—	—	—	—
Scotophilus heathi	1	—	—	—	—	—	—	—	1	—	—	—	—
Macaca mulatta	72	—	—	17	23	16	—	—	—	7	9	—	—
Presbytis entellus	40	—	1	22	2	—	—	—	—	—	15	—	—
Manis crassicaudata	1	—	—	—	—	—	—	—	—	—	—	1	—
Vulpes vulpes	1	1	—	—	—	—	—	—	—	—	—	—	—
Sus scrofa	1	—	—	—	—	—	—	—	1	—	—	—	—
Antilope cervicapra	3	—	—	—	—	—	—	—	2	1	—	—	—
Gazella gazella	3	—	—	—	—	—	—	—	2	1	—	—	—
Funambulus pennanti	10	—	—	—	—	7	3	—	—	—	—	—	—
Rattus rattus	10	—	—	—	—	8	2	—	—	—	—	—	—
Tatera indica	9	2	3	—	—	—	—	—	—	2	2	—	—
Meriones hurrianae	13	—	—	—	—	—	—	—	—	3	5	5	—
No. litters born	—	3	4	39	32	47	17	4	19	17	31	6	0
No. species born	—	2	2	2	3	5	3	2	7	6	4	2	0

living conditions exist either during or immediately after the rainy season, and thus most species breed during this period.

SUMMARY

Mammals of 38 species and subspecies were collected from Rajasthan Desert, India; 19 of these species contributed breeding data. There is no common breeding season for all mammals, although breeding of each species is cyclic. Mammals breed in all months except December. Most species breed during the period of maximum precipitation.

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AN EMBALMING TECHNIQUE FOR PRESERVING SMALL MAMMALS

BY EDMOND C. LOOMIS

Accurate field identification of small mammals is often difficult and frequently demands storage of specimens until they are returned to the laboratory. For best results, museum study skins are usually prepared immediately after capture. For temporary preservation, however, skins have been immersed in salt-alum solution, a formalin-phenolglycerin mixture, or dry-wrapped in powdered arsenic-borax. Schultz (1924) employed arterial injection of larger mammals similar to the laboratory technique for embalming cats, dogs and monkeys. When processing small mammals, he used the technique of injecting specimens directly in several body regions. A mixture of five parts of glycerin to 100 parts of 10 per cent formaldehyde was used. Animals were then immersed in 10 per cent formaldehyde for at least 24 hours and maintained in the fluid if permanent storage was desired. Booth (1944) also used an embalming fluid consisting of phenol, glycerin, 100 per cent formaldehyde, and water in parts 10:10:10:70 respectively. Penetration was increased by the addition of 5 per cent glacial acetic acid (amount not stated). Anderson (1948) recommended injection or immersion of specimens in 4 per cent formaldehyde or, less desirably, in a solution of carbolic acid or lysol. Hall (1937) and Elton (1938) objected to the use of most mammal preservatives because of the resulting color changes in the pelt and the general stiffness of the skin.

The need for accurate laboratory identification of small mammals stimulated a search for a suitable field-preservation technique. The technique had to be simple, rapid and inexpensive for field use by disease surveillance and small mammal census survey personnel working within four vector control operational zones comprising the entire state of California.

MATERIALS AND METHODS

The study included both laboratory and field tests. The embalming fluid used in these tests is sold commercially under the trade name "Trioxitone." The chemical components consist of the following: formaldehyde, denatured alcohol (95 per cent ethyl plus a trace of methyl), zephiran chloride ("Roccal"), and water. Dilutions were made with distilled water.

Laboratory tests were conducted on white mice and wild-trapped specimens of *Rattus norvegicus*. Mice were inoculated with fluid in dilutions ranging from 1:1 to 1:8. The amount of fluid inoculated was 0.20 to 0.25 milliliters per gram body weight (ml/g.b.w.). Norway rats were inoculated with a 1:2 dilution of fluid at the dose of 0.2 ml/g.b.w. The brain cavity was pierced through the occipital foramen. Inoculations were made at the base of the sternum and the mid-inferior surface of the abdomen. Care was taken to distribute fluid through all parts of the abdomen. Both thighs were inoculated at the mid-point of the femoral triangular surface. In addition, the region around the anus was inoculated. All specimens were kept at room temperatures (21° to 26°C.) in covered cardboard boxes and were examined daily for odor, hair slippage, body rigidity and pelt shrinkage.

Animals in field tests were inoculated with 0.25 ml/g.b.w. of a 1:1 dilution of the fluid. Five rodents were inoculated by Dr. D. P. Furman, University of California, while trapping small mammals in central and southern Mexico. A 1:1 dilution of fluid was injected until the specimens became firm. These specimens were reinoculated in transit to the laboratory because of the excessive heat and humidity.

RESULTS

In the laboratory tests, 19 mice were inoculated five minutes after chloroforming. Specimens inoculated with a 1:2 dilution or less were successfully preserved and skinned seven days after inoculation. Shrinkage of tails occurred in nearly all specimens after five days and hair slippage was evident in a few animals seven or more days after inoculation. As evidenced by odor and hair slippage, several specimens given greater dilutions deteriorated within two to four days after inoculation. Five snap-trapped Norway rats were inoculated after an estimated 14–26-hour lapse from time of capture. Perfect skins were obtained from two rats eight days after inoculation. The remaining three rats had hair slippage within two to five days after inoculation. Failures with these latter specimens may have been due to a longer interval of time between capture and inoculation of embalming fluid. Because of these results, two mice each were inoculated at intervals of 6, 8, 10 and 12 hours after death, with a 1:1 dilution of fluid. The mice injected six hours after death were in excellent condition five days later. The mice inoculated eight hours after death were satisfactory three days later and specimens inoculated 10 and 12 hours after death were unsatisfactory after one day.

Field tests were conducted in California on the following 17 rodents: *Citellus beecheyi* (3), *C. leucurus* (3) and *C. mohavensis* (1); *Dipodomys merriami* (2) and *D. panamintinus* (1); *Onychomys torridus* (2); *Neotoma fuscipes* (2); *Peromyscus californicus* (1); *Perognathus californicus* (1); and *Thomomys bottae* (1). All animals were snap-trapped except *C. beecheyi*, which was shot.

The three *C. beecheyi* were inoculated 1, 4 and 6 hours, respectively, after death. All three were in virtually perfect condition when skinned five and six days later. Slight hair slippage occurred on the tail of one specimen. The snap-trapped specimens of *Citellus* were inoculated six hours after death. All four were in excellent condition seven days later. Kangaroo rats presented the principal difficulty in preparing museum skins since the skin of their tails came free from the muscle sheath. The specimens of *Onychomys* were well preserved six days after inoculation except that their feet and noses were extremely dry. The wood rat proved satisfactory two days after inoculation, but the skin of the tail also tore loose from the muscle sheath. Slight hair slippage occurred on the abdomen of the *Peromyscus* but identification proved satisfactory six days after inoculation. Excellent museum skins were made from the *Perognathus* and *Thomomys* specimens six days after inoculation.

The rodents collected in Mexico were *Peromyscus evides* (2), *Baiomys musculus* (1), and *Liomys irroratus* (2). These gave surprising results. The *Peromyscus* were in excellent condition when identified after 18 days of preservation, as were *Baiomys* and *Liomys* after 28 days. Although the exact dosage of fluid to be used was not calculated, the skins were in excellent condition. This may have been due to their being reinoculated once (*Peromyscus*) or twice (*Baiomys* and *Liomys*) during field storage. Body shrinkage occurred with specimens of *Baiomys* and *Liomys* as shown by measurements taken at the time of capture.

DISCUSSION

The initial objective of developing a simple, rapid preservative to enable subsequent identification of small mammals was attained. Specimens usually reach the laboratory within four days from any point of shipment in California, and are in good condition. Identification can be accomplished after considerably longer time intervals. If study skins are to be prepared, however, this must usually be done within a week after inoculation. The moderate amount of stiffness in embalmed specimens slightly increases the difficulty of making study skins. The technique is particularly useful for collectors who obtain freshly killed animals and must hold them until a later time. The difficulty of preparing a large series of skins in hot weather can be minimized by light abdominal inoculations of fluid, thereby delaying putrefaction. Although tests were not conducted on other animals, it is probable that birds can be similarly preserved.

The most important factor in the technique is promptness in inoculating animals after death. Animals must be removed from snap traps while relatively

fresh. Best results will be obtained with specimens that are live-trapped or shot. If field surveys are conducted in areas where extremely hot and humid conditions prevail, it may be desirable to reinoculate specimens in transit.

Repeated experience with this technique has provided minor changes and several recommendations for field use. The use of undiluted embalming fluid increases the probability of satisfactory preservation. The dosage is roughly calculated at ⅛ to ½ milliliter per gram of body weight. Most of the fluid is injected into the abdomen but smaller amounts are injected into the chest, shoulders and thighs. Care is taken not to inject so much fluid that the animal becomes swollen and fluid leaks out; in some animals this causes minor bleaching of the pelage. The brain is inoculated only if the occipital foramen can be found and the needle easily inserted. The brain is often more difficult to remove once it has been injected. Inoculation of the brain, however, has not prevented subsequent cleaning of the skulls by dermestid beetles. It also is advisable that measurements be made of the feet, ears and tail at time the animal is captured, since these parts undergo drying and shrinkage.

Laboratory tests described by the U. S. Public Health Service in 1953 showed that both plague- and tularemia-infected rodent carcasses were free of these bacilli two days after inoculation with Trioxitone.

SUMMARY

A technique is described for small mammal preservation, utilizing human cadaver embalming fluid. Laboratory tests were conducted on white mice and Norway rats, and field tests were made in California and Mexico on shot and snap-trapped rodents. The interval between time of death and inoculation of fluid was found to be important for successful preservation. In general, animals were successfully preserved for seven days. Extremes of 18 and 28 days' preservation resulted with animals reinoculated during field storage. All preserved specimens proved satisfactory for identification. Those processed within determined time limitations were satisfactory for museum study skins.

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GENERAL NOTES

THE OPOSSUM IN NEW MEXICO

Until now, the opossum, *Didelphis marsupialis*, has been reported only as a straggler in New Mexico. According to Bailey (N. Amer. Fauna 53: 7, 1931), Hugh Campbell of Monahans, Texas, wrote on 14 April 1909 that a few opossums had been taken there and that he knew of one instance of their occurring on the New Mexico side of the line. Bailey also pointed out that opossums may follow the Canadian River Valley into New Mexico as the animals have been reported from Tascosa, Oldham County, Texas, and from Baca County, Colorado.

Two opossums from Belen, Valencia County, New Mexico, now reside in the University of New Mexico Collection of Vertebrates. These specimens were collected by R. K. Dunlap, a biologist with the New Mexico Game and Fish Department. One was collected on 22 November 1956, and one the preceding summer. Both animals were found dead on U. S. Highway 85, 3 miles north of Belen.

Additional inquiries have since led to more records. In 1952, an opossum was found and held captive by a man at Los Chavez, 4 miles north of Belen, and was identified by Dunlap. In December of 1955, Dunlap observed an opossum inside the Belen Wagon Bridge Refuge. He reports that opossum tracks have been seen since that time near the refuge and elsewhere in the vicinity of Belen. On 2 February 1956, the Wool Warehouse Company in Albuquerque purchased an opossum pelt from a man who was trapping in the Albuquerque area. During the summer of 1958, Don Findley of Albuquerque observed an opossum at a garbage dump on State Road 10, between the towns of Tijeras and San Antonio in Bernalillo County. In early February 1959, Charles Caton, a student at the University of New Mexico, observed an opossum 1 mile south and 1 mile east of Ragland, Quay County, New Mexico.—James L. Sands, *New Mexico Dept. of Game and Fish, Albuquerque.* *Received 4 June 1959.*

NOTES ON *MYOTIS THYSANODES* IN UTAH

In their revision of the bats of the genus *Myotis* (U. S. Nat. Mus., Bull. 144: 122–130, 1928), Miller and Allen included most of Utah within the geographical range of *Myotis thysanodes thysanodes* Miller, although evidence of the occurrence of this bat in the state was not available. The nearest records of occurrence were from Arizona, represented by three specimens (*op. cit.*: 127) and they remained as such until 1946, when Hall in his Mammals of Nevada (Univ. Calif. Press, pp. 138–139) recorded 16 specimens from 6 mi. S St. Thomas, Clark County, Nevada, approximately 45 miles southwest of the Utah-Nevada state boundary (*op. cit.*: 138).

When Durrant wrote the Mammals of Utah (Univ. Kansas Publ., Mus. Nat. Hist., 6: 475, 1952), he placed *M. t. thysanodes* in a hypothetical list, stating that no specimens of the fringed myotis were known to him. Since that time, two adult male specimens were reported from 4 mi. N Thompson, Grand County, Utah, by Krutzsch and Heppenstall (Jour. Mamm., 36: 126, 1954). A series of eleven specimens, one adult male and ten adult females, No. 14658–14668 inclusive, Museum of Zoology, University of Utah, were taken by Guy G. Musser, R. Jean Stout, and Gerald R. Smith, at Pine Valley, 20 miles (airline) north of St. George, elevation 6,500 feet, Washington County, Utah, on 14, 15 and 21 June 1958.

This last record is worthy of note because it represents the first occurrence of these bats in appreciable numbers in the state, and the first ever reported from western Utah. Moreover, this is the first time sufficient material has become available for taxonomic evaluation.

The eleven specimens were part of a colony estimated to contain approximately 35 individuals found roosting in the dark attic of an old pioneer church house, built in 1868. The attic was completely enclosed except for the usual cracks and crevices characteristic of

an old building, with the only exit consisting of open shutters on the sides of the belfry. The interstices between the supporting timbers of the roof proved to be the roosting areas of the bats. Arousing the bats and forcing them to fly within the confines of the attic facilitated easy capture by the use of an insect-collecting net.

Miller and Allen (*op. cit.*: 126) stated that, under natural conditions, members of this species are no doubt cave dwellers, although most of the specimens they examined were obtained from old ruins and dark attics of abandoned buildings. The location of the colony referred to above substantiates the idea that these bats prefer old buildings as dwelling places. This is especially apparent when considering the number of caves, particularly in Utah, which have been collected and yielded no specimens of the fringed myotis. Indeed, throughout the entire range of *M. thysanodes*, most of the known specimens have been obtained from abandoned buildings (Hall and Kelson, MAMMALS OF NORTH AMERICA, Ronald Press, p. 170, 1959).

Inasmuch as this is the first record of the fringed myotis in large numbers in Utah, we deem it advisable to record the average and extreme measurements of the eleven specimens, which are as follows: Total length, 85.6 mm. (80.0–92.0); tail vertebrae, 39.4 (37.0–42.0); hind foot, 9.1 (8.0–10.0); ear from notch, 17.4 (16.0–19.0); tragus, 10.0 (9.0–11.0); length of forearm, 42.5 (41.5–44.5). Skull: Condylobasal length, 16.4 (16.1–16.6); palatal length, 9.0 (8.8–9.2); zygomatic breadth, 9.9 (9.6–10.2); mastoidal breadth, 8.1 (7.9–8.3); interorbital constriction, 4.1 (4.0–4.3); breadth of braincase, 7.8 (7.4–8.0); occipital depth, 5.6 (5.4–5.8); length of dentary, 12.0 (11.9–12.2); maxillary tooth row, 6.4 (6.3–6.5); maxillary breadth at M^3, 6.6 (6.4–6.8); mandibular tooth row, 6.8 (6.6–7.1). In color these eleven specimens generally agree with the description given by Miller and Allen (*op. cit.*: 127) save some specimens which possess lighter buffy-tipped hairs, giving them a more pallid appearance. In this they approach those specimens reported by Krutzsch and Heppenstall (*op. cit.*: 126) from eastern Utah.

The external and cranial characters of the eleven specimens fall within the range of variation of *Myotis thysanodes thysanodes* Miller, given by Miller and Allen (*op. cit.*: 128–130) and Hall and Kelson (*op. cit.*: 170), thus making them clearly referable to this subspecies.—GUY G. MUSSER AND STEPHEN D. DURRANT, *Dept. of Zoology, Univ. of Utah, Salt Lake City. Received 25 May 1959.*

PROBABLE BREEDING AND ADDITIONAL RECORDS OF THE SEMINOLE BAT IN NORTH CAROLINA

On 6 July 1955 George Tregembo, owner of a small zoo on highway U. S. 421 approximately 10 miles south of Wilmington, New Hanover County, North Carolina, noticed a peacock attacking something on the ground in its cage. On examination he discovered it to be a badly mangled immature bat. Further search revealed a second bat hanging in a corner at the top of the cage. Both of the specimens were turned over to the junior author who recognized them as young Seminole bats, *Lasiurus seminolus*, and probably litter mates as both were identical in size and unable to fly. The mother could not be located. However, a lactating, non-pregnant *L. seminolus* was shot as it fed over the same cage at 7:45 PM on 9 July 1955. An adult male of the same species was collected in the same area on 11 July 1955. In view of the stage of development of the young bats, it is believed that they were born in the immediate vicinity. The measurements of the non-mutilated young bat, a male, are TL-72, TV-30, HF-8, E-9. Measurements of the other specimen were not taken, nor could its sex be determined.

A fifth specimen was collected by the junior author on 13 July 1955, at Wrightsboro, New Hanover County, North Carolina, as it flew over a paved road separating cultivated fields and a grove of longleaf pine (*Pinus palustris*) with an understory of wire grass (*Aristida stricta*). Several other individuals believed to be Seminole bats were also observed during this collecting trip. All were feeding over sand ridge areas which are covered with an open

stand of longleaf pine and with a turkey-oak (*Quercus laevis*) and wire grass understory. No Seminole bats have been observed or collected along the water courses although the red bat, *Lasiurus borealis*, is frequently seen and taken along coastal streams.

It is believed that the young specimens constitute the first breeding record of the Seminole bat in North Carolina as the collecting locality is approximately 40 miles from the South Carolina boundary. The five specimens reported above also represent the first records of this bat from the Coastal Plain of North Carolina, all other records from the state being from the Piedmont region (Barkalow and Adams, Jour. Mamm., 36: 453–454, 1955). —F. S. Barkalow, Jr. and J. B. Funderburg, Jr., *Dept. of Zoology, North Carolina State College, Raleigh. Received 15 July 1959.*

A SMALL COLLECTION OF BATS FROM ANGOLA

There is a small group of bats in the Peabody Museum of Natural History, Yale University, principally from Dundo, Lunda, northeastern Angola, collected by Gerd Heinrich. One species represents a new record for Angola and another is here reported for the second time.

Hypsignathus monstrosus H. Allen.—Dundo (Rio Luachimo), 15 Feb. 1958, 1 ♀, P. M. No. 9083; skin and skull. Sanborn (*Publ. Cult. Companhia Diamantes Angola*, No. 10: 53, 1950) reported the only previously known specimen from Angola, though this is a common species in the Belgian Congo. The present specimen is larger than previously described females. Collector's note—tangled tropical gallery wood, altitude 800 m., weight 302 g.

Epomophorus wahlbergi haldemani (Hallowell).—Carlo, 15 Jan. 1958, 1 ♀, P. M. No. 9082; skin and skull. This appears to be a common bat in Angola. The present specimen has a rather small skull. Collector's note—altitude 1,400 m., weight 73 g.

Epomops franqueti franqueti (Tomes).—Dundo (Rio Luachimo), 25 Feb. 1958, 1 ♀, P. M. No. 9086; 1 March 1958, 1 ♂, P. M. No. 9088; skins and skulls. This bat appears to be uncommon but has been collected in Angola before (Hill and Carter, *Bull. Amer. Mus. Nat. Hist.*, 78 (1): 31–33, 1941). Collector's note—tropical gallery wood, altitude 800 m., weights 84 g. (♀) and 105 g. (♂).

Megaloglossus woermanni Pagenstecher.—Dundo (Rio Luachimo), 1 ♂, 26 Feb. 1958, P. M. No. 9085; 1 ♀, 26 Feb. 1958, P. M. No. 9087; skins and skulls. This is the first record of this species from Angola. It is known from the Belgian Congo where it is considered rare (Schouteden, *Ann. Mus. Congo Belge Tervuren*, Ser. 8°, Sciences Zool., 1: 71, 1948; Hayman, *Rev. Zool. Bot. Afr.*, 50: 282, 1954) and the rain forest further north (Andersen, Catalogue of Chiroptera. Vol. I. Megachiroptera. Brit. Mus. [Nat. Hist.], p. 746, 1912). Collector's note—tropical gallery wood, weights 16 g. (♂) and 16.5 g. (♀), altitude 800 m.—Alvin Novick, *Dept. of Zoology, Yale Univ., New Haven 11, Connecticut. Received 29 June 1959.*

TWO NEW RECORDS FOR MACROGLOSSINE BATS

Two bats in the Peabody Museum of Natural History, Yale University, collected by S. Dillon Ripley, represent new geographic records.

Macroglossus lagochilus nanus Matschie.—Dola, Gng. Djailolo, Halmahera, Indonesia; 6 September 1954, 1 ♂, collector's no. 1; skin and skull; weight 15 g. This bat apparently has not been collected before from Halmahera though it is known from New Guinea and several adjacent islands (Laurie and Hill, Mammals of New Guinea and Celebes, Brit. Mus. (Nat. Hist.), p. 44, 1954; K. Andersen, Catalogue of Chiroptera, Vol. I Megachiroptera; Brit. Mus. (Nat. Hist.), p. 752, 1912).

Syconycteris crassa papuana (Matschie).—Tamulol, Misool Is., Netherlands New Guinea; 17 November 1954, 1 ♀, collector's no. 4; skin and skull; weight 15 g. This bat

has not previously been recorded from Misool Island though it is known from New Guinea proper and the Aru Islands (Laurie and Hill, *op. cit.*, p. 44; Andersen, *op. cit.*, p. 778).—Alvin Novick, *Dept. of Zoology, Yale University, New Haven 11, Connecticut.* *Received 29 June 1959.*

COMMENTS ON THE ODORS OF BATS

Very few data have been gathered on the role that odors and olfactory response play in the life of the bat. This is somewhat unusual, since many forms are well known to have strong body odors. An interesting observation made by Dunn (Jour. Mamm., 14: 188–199, 1933; 15: 89–99, 1934) was that there appeared to be a difference between the odors of the male and female little bulldog bat, *Dirias albiventer minor*. The male was described as having a more pronounced musky smell than the female. During recent ecological studies on the Mexican free-tailed bat, *Tadarida brasiliensis mexicana* (Saussure), in Texas, a similar difference in the odor between sexes was noted. This was recognized early in November 1957 when the two sexes were temporarily separated in pint ice cream containers. Although the odors became increasingly easy to separate the longer the animals were held within their containers, the bats themselves, when placed close to the nose, were seldom distinguishable as to sex. The females had a duller, more musk-like odor, while the males were characterized by a "sweeter" and stronger odor. This difference persisted throughout the month of November and at least part of December when observations were stopped due to the movement of bats away from the central Texas caves. By March 1958, when the bats were again in this region, they had apparently lost the sexual difference in odor that had been so striking in previous months; both males and females presented the same odor as was earlier only characteristic of the females. Periodic checks of the bats did not reveal any changes until 23 October 1958, when again some of the males had developed their "sweet" odor. Since no difference was detected the previous week, it is presumed that the date given for the initial occurrence of the male odor, which corresponds quite closely to observations made in 1957, gives a fairly accurate idea when the odor was strong enough to be noted as described above.

Speculation on the causes of this odor change leads one to consider what hormonal variations are occurring during this period. Sherman (Jour. Mamm., 18: 176–187, 1937) indicated that the testes of the closely related Florida free-tailed bat, *T. b. cynocephala* (LeConte), began their recrudescence in September–October, attained their peak size in February, and diminished to a "resting" level during May–August. A similar cycle occurs in *T. b. mexicana* (Courier, Arch. Biol., 37: 173–334, 1927; Hartman, Quart. Rev. Biol., 8: 185–193; R. B. Davis, unpublished). This suggests that the "sweet" odor may be due to the initiation of testicular activity or associated endocrine changes which stimulate glandular secretions on the bat's body. A sexual difference in body odor might serve to increase the ease of contact between sexually active males and females during the ensuing spring mating season or might aid in the segregation of the sexes.

This study was supported by a grant from the National Institutes of Health and directed by D. E. Davis.—Clyde F. Herreid II, *Division of Vertebrate Ecology, Johns Hopkins Univ., Baltimore 5, Maryland.* *Received 13 April 1959.*

RESPONSES OF FREE-TAILED BATS TO INCREASES IN CAVE TEMPERATURE

Bracken Cave, 20 miles northeast of San Antonio, Comal Co., houses a breeding population of *Tadarida brasiliensis mexicana* estimated at 20 million individuals (Eads *et al.*, Tex. Jour. Sci., 9: 227–242, 1957). The cave has been the collecting site for several researches, including a war-time weapons development project and a rabies research program presently being conducted by the Texas State Department of Health (Irons *et al.*, Tex. Rep. Biol. Med., 15: 292–298, 1957). It is small, consisting of one large room approximately 1,000 feet long, 100 feet wide, and 75 feet high, and a smaller domed chamber, 30 feet in

diameter and 125 feet in height. This room is connected to the first near its deeper reaches through an opening nearly 15 feet wide and 50 feet high. The wide entrance is high on one wall of the larger room and measures 12 by 40 feet.

During May, June and July of 1958, I visited the cave and made observations of the behavior of the population during a period of increasing temperature inside the cave. On 24 May, the bats inhabited mostly the darker portions of the cave; few were closer to the entrance than 50 feet. On the wall opposite the entrance, adults were spaced about 2 to 3 inches apart. In the lower crevices and recesses the younger bats were crowded together in densities up to 150 per square foot. There was a nursery measuring 20 × 30 feet on one wall where young were deposited in specific age groups, in densities estimated up to 300 individuals per square foot for the smallest size category. These were piled four deep in some crevices. Nursing females were sparsely scattered throughout in a ratio of 1 per 25 or more young. Eads (*op. cit.*) has observed many females hanging adjacent to the nursery.

An estimated 1 per cent of the population was constantly in flight throughout the day, always moving in a counterclockwise direction in both rooms. This produced a noticeable whirling air movement, presumed to be important in removal of air, toxic with ammonia from the bats' urine.

During the two months the cave was visited, the average outside temperature slowly increased from 75° to 84°F., the average rainfall varied from nearly 2 inches in May to more than 7 inches in July, and the average relative humidity remained about 67 per cent (Table 1). The temperature in the cave, 5 feet above the floor, was higher than the outside temperature for all observations, increasing from 95° on 24 May to 99° on 12 July. It is presumed that the elevated temperature resulted from the large number of bats that were always active, and from the decomposition of the guano, as much as 2 feet deep on the level.

TABLE 1.—*Monthly averages of climatological conditions and cave temperatures. In part from Local Climatological Data charts for San Antonio, Texas, U. S. Weather Bureau, 1958. Cave records made by the author.*

MOUTH	TEMPERATURE° F.		PRECIPITATION, IN.		RELATIVE HUMIDITY %	CAVE TEMPERATURE° F., AND DATES TAKEN	
	Avg.	Dep.	Avg.	Dep.			
May	75	−0.9	2	−1.9	68	95	24 May
June	83	+0.8	3.4	+0.2	67	97	14 June
						98	28 June
July	84.5	+0.3	7.4	+5.5	66	99	12 July

As temperature rose in the cave, the behavior of the population changed perceptibly. Where adult bats had not roosted nearer than 25 or 30 feet from the entrance in open areas in May, they were found hanging within 10 feet of it on 14 June—well into the twilight zone. By 12 July, many adults were clinging to the underside of the limestone bluff overhanging the entrance, in full daylight.

On 28 June, an estimated 2 per cent of the population was in constant flight, and on 12 July about 10 per cent were circling the two chambers, producing a strong hot wind from the mouth of the cave. Despite this increased flying, the ammonia in the air at the bottom of the cave increased in concentration to a point where I had great difficulty in breathing. Of the individuals that had previously hung in the higher portions of the cave, on the walls or ceiling, only a very few remained roosting in July, but these appeared very irritable and many took flight upon slight disturbance. Where great numbers of juveniles had collected in interstices of the rocks in May, few remained in July. Most individuals were now clinging to the rock projections or more open surfaces of the lower portions of the walls.

A few points may be drawn from this. The bats became more irritable while hanging because the cave temperature now approached active body temperatures. With increased

irritability, more individuals were flying. As environmental temperature increased, with no decrease in relative humidity, circular flying became less efficient both in ammonia removal and in temperature-lowering efficiency. With the temperature increases in the heights of the cave, the bats moved outside the entrance into bright daylight to obtain a cooler roosting site. Thus the behavior of a population of bats may serve at least two functions: (1) increased flying to partially aid in air circulation in the cave, and (2) changing of roosting sites to avoid high temperature conditions.

Grateful acknowledgment is made here to W. H. Burt, W. R. Dawson and F. E. Smith for their kind aid in preparation of this manuscript.—ROBERT E. HENSHAW, *Dept. of Zoology, Univ. of Michigan, Ann Arbor.* *Received 22 June 1959.*

INJURIES DUE TO BAT BANDING

The following study was started in 1956 and extended through 1959 to supply some quantitative information on the importance of band injuries to the survival of the Mexican free-tailed bat, *Tadarida brasiliensis mexicana* (Saussure). During the progress of this work, it became apparent that considerable injury was caused by the use of the bird band. In order to reduce this injury, the new bat band (series 10–00001 to 10–40000) was manufactured and distributed. This report is an attempt to compare quantitatively the injuries caused by the two types of bands.

The work was directed by David E. Davis and supported by grant E1040 from the National Institutes of Health. John Wood and David Cragie assisted in gathering some of the data. Other banders that have been particularly active in the southwestern part of the United States and Mexico and most helpful in various phases of our work are the Texas State Health Department, Bryan P. Glass, Denny G. Constantine and Bernardo Villa R.

Methods.—Bird bands of the size 0 and 1, supplied by the U. S. Fish and Wildlife Service, and the new bat bands of comparable size were placed on the forearm of adult free-tailed bats in the manner of Trapido and Crowe (Jour. Mamm., 27: 224–226, 1946). Considerable care was taken not to close the bands completely to the wing membrane. When a banded individual was recovered he was examined and any band injury that occurred was described and recorded in detail. A total of 573 recaptured bats bearing bird bands and 252 bats with bat bands were examined. Although some of the bands were placed by other banders, these data are included because there was no apparent difference in the level of injury on these animals when compared to our banded bats.

Although we arbitrarily divided the types of band condition into four broad categories, there were many variations and complications of each. (1) A bat was considered to be in *good* condition if no irritation was observed. (2) *Irritation* was recorded as the first outward sign of some injury caused by the band. This condition was characterized by the presence of pus and rawness where the skin had been worn away. (3) *Wing tear* was apparently the result of the repeated rubbing action of the rough front edges or corners of the band on the flight membrane of the wing. The band evidently wore through the wing membrane, causing a tear often large enough for the band to revolve freely about the forearm. Healing occasionally occurred at this stage to the torn edges of the membrane. (4) On many occasions a band was found to be *embedded* in the flesh of the forearm. This condition was characterized by considerable swelling of the forearm under and around the band and a tendency for scar tissue to grow over the band. Complete healing was seldom noted and pus and scabbing usually were evident. In many cases of the "embedded" type of injury, the front edges of the bird band were found to be deep in the flesh and partially embedded in the bone.

The bird band.—To analyze the data obtained on injury, the information was arrayed in terms of the length of time that a band was on a bat. These data have been tabulated in terms of percentages in Table 1. Since some bats had forearms with both wing tear and

TABLE 1.—*Injury due to bird bands.*

DAY INTERVAL	TOTAL BANDS RECAPTURED	PER CENT GOOD	PER CENT IRRITATION	PER CENT WING TEAR	PER CENT EMBEDDED
0– 10	36	56	17	8	22
11– 20	141	48	13	13	37
21– 30	44	25	7	23	59
31– 40	49	26	10	16	59
41– 50	21	19	5	24	57
51– 60	28	32	7	29	36
61– 70	33	30	9	27	42
71– 90	32	31	9	41	31
91–100	30	20	3	47	47
101–120	24	17	0	54	42
121–180	22	18	4	27	59
181–300	27	26	7	18	48
301–360	43	58	0	7	35
361–730	43	35	7	23	37

embedded injuries, the same bat may occur in both categories. The percentage of double injury (both wing tear and embedded) was generally at a low level, varying between 0 and 17 per cent. Although the small number of animals representing many of the intervals does not allow us to make a detailed analysis of the data, we feel that certain major trends are apparent and warrant discussion.

First is the marked decrease in the percentage of bats with good bands which occurred until the end of the first month, when a low of 25 per cent was reached. Thereafter, with one major exception, the percentage of bats in a good condition remained under 35 per cent! As might be expected, "irritation" reached its maximum at 17 per cent within the first ten days after banding, and continued to play only a minor role in the injury data. This is consistent with our previously stated belief that "irritation" was a temporary stage that gave way to the more "serious" types. "Wing tear" showed a steady increase with a maximum of 54 per cent of the bats having this condition in the latter part of the fourth month. In the embedded category, a maximum was attained by the end of the first month as 59 per cent. Although there apparently was some decrease in the second and third months, the embedded class generally exceeded 40 per cent. Up to the 61–70-day interval there were only three cases of bone injury, but after that period there was a decided shift to the more advanced embedded condition.

The new bat band.—Since it appeared that most of the injuries were either due to or greatly enhanced by the sharp corners of the front edges of the bird band, a German-type bat band (Hitchcock, Jour. Mamm., 38: 402–405, 1957) was manufactured and tested. This

TABLE 2.—*Injury due to bat bands.*

DAY INTERVAL	TOTAL BANDS RECAPTURED	PER CENT GOOD	PER CENT IRRITATION	PER CENT WING TEAR	PER CENT EMBEDDED
0– 10	49	71	14	4	10
11– 20	42	69	14	12	5
21– 30	26	50	11	8	31
31– 40	35	34	9	29	29
41– 50	31	45	3	13	39
181–300	33	27	0	67	6
361–730	36	36	3	56	6

band has the corners of the front edges somewhat rounded off and a small lip turned back at each end so that these broad surfaces rather than the rough band edges make contact with the wing membrane.

In comparing the two bands (Tables 1 and 2) there are two points to be stressed. First, the new bat band clearly causes injury at a slower rate than the bird band. However, it is important to note that by the 181–300- and 361–730-day interval the percentage of good bands in the field was about the same for both bands. The second fact that needs consideration is that there is a decided difference in the type of injury usually caused by the two bands. The bat bands clearly caused fewer embedded injuries than did the bird bands. This was particularly evident after the bands had been on the bats for some time. It is further significant that no embedded-in-the-bone injuries were ever noted with the bat band, and that only a few double injuries occurred. In addition to the above, the percentage of wing tear caused by the two bands was relatively similar soon after banding, but by the 181–300- and 361–730-day interval the bat bands had caused considerably more wing tear than had the bird bands. Fifty per cent of the wing tears caused by the bat band were injuries that were well healed.

Although there is little question that the use of the new bat band, at least in marking *Tadarida*, will greatly reduce both the rate and seriousness of band injury, it is hoped that additional modification (e. g., broadening of the band lip and more rounded corners) will further reduce the injuries and perhaps deaths of many banded bats.—Clyde F. Herreid II, Richard B. Davis and Henry L. Short, *Laboratory of Comparative Behavior, School of Hygiene and Public Health, The Johns Hopkins Univ., Baltimore, Maryland.* *Received 31 July 1959.*

SEMINOLE BAT STRANGLED BY SPANISH MOSS

A dead bat was discovered on the ground under a solitary sweet gum tree (*Liquidambar styraciflua*) near pond No. 12 on the U. S. Fish Cultural Station at Orangeburg, S. C., on 30 March 1954. The tree was lightly draped with Spanish moss (*Tillandsia usneoides*). Fred Downs first noticed the bat, which was identified by the writer as a Seminole bat, *Lasiurus seminolus*. It had five or six strands of dead Spanish moss twisted tightly around its neck and several green pieces of the same plant in its mouth. Judging from the appearance of the "noose", it seemed that the bat had spun around, head down, in a clockwise direction.

The specimen was in an advanced stage of decomposition and desiccation, and an attempt to make a study skin was unsuccessful. The bat was preserved in alcohol and is in the possession of the writer. It is probably a female, but, because of the condition of the specimen, this identification is not positive.

Apparently Spanish moss is regularly used for shelter by Seminole bats (Constantine, Jour. Mamm., 39: 64, 1958). Is such a death uncommon, or are many bats strangled or hopelessly entangled by Spanish moss?—Paul B. Dunaway, *Oak Ridge National Laboratory, Oak Ridge, Tennessee.* *Received 21 July 1959.*

STUHLMANN'S BLUE MONKEY IN THE KAYONSA FOREST, UGANDA

The southern limit of distribution of Stuhlmann's blue monkey, *Cercopithecus mitis stuhlmanni*, in Uganda is generally considered to be a line that extends from Lake George to Masaka. South of that line, the forms of *C. mitis* that have been recorded or collected in Uganda are the silver monkey, *C. m. doggetti*, a denizen of the papyrus swamps that occupy marshy lowlands and valley-bottoms of southwestern Uganda, and the golden monkey, *C. m. kandti*, an inhabitant of mountain bamboo forests.

On 31 October 1958, C. Jackson Selsor and the author encountered four groups of *C. m. stuhlmanni*, all of which were south of the hypothetical line that supposedly separates the ranges of the three forms in question. The first Stuhlmann's blue monkey was observed at a distance of 10 feet at an altitude of approximately 6,000 feet on the northern edge of the Kayonsa Forest. The monkey was feeding in a low tree in hillside forest alongside the Luhiza Road about 55 miles (by road) north of Kisoro, Kigezi District. A group of four specimens was observed at 25 feet as they fed on bamboo shoots at an altitude of approximately 7,000 feet and about 15 miles nearer Kisoro on the same road. At the same stop, another group of three was noted nearby. A single male was seen in a broad-leaf tree near the 8,000-foot marker which was roughly 4 miles south of the point where the seven examples were encountered in the bamboo patch.

Thus it appears that three distinct and readily distinguishable forms of *C. mitis* occur within the confines of the Kayonsa Forest: the silver monkey in valley-bottom stands of papyrus; Stuhlmann's blue monkey in mountain broad-leaf forests and adjacent bamboo patches; and the golden monkey in the extensive stands of bamboo on the higher slopes.—Ken Stott, Jr., *Natural History Museum, Balboa Park, San Diego, California.* *Received 30 April 1959.*

NOTES ON REPRODUCTION IN CAPTIVE MARMOSETS

A pair of lion marmosets, *Leontideus rosalia*, kept at the Chicago Zoological Park for 2½ years produced four sets of twins. The interval between the second pair, born alive on 12 February 1951, and the third pair, stillborn but not premature, on 25 June 1951, allows a maximum gestation of 134 days. The only previous independent record for this species is that of Jennison (Table of gestation periods and young; London, 1927), which gave no details beyond the figure of 140 days. We have found no other records for the normal-incisor marmosets, and two records of 142 and 150 days for *Callithrix jacchus* (Lucas *et al.*, Proc. Zool. Soc. London, 107A: 205–211, 1937) seem to be the only information for the long-incisor group.

Recently a black-mantled tamarin, *Saguinus* (*Saguinus*) *nigricollis*, aborted two well-developed young (crown-rump 75 mm.). The umbilical cords of the fetuses were attached to separate discoidal placentae that were in close anastomosis. This is one of the conditions described for *Saguinus* (*Oedipomidas*) *geoffroyi* by Wislocki (Amer. Jour. Anat., 64: 445–483, 1939) and reported for *Callithrix* by J. P. and C. J. Hill (Jour. Anat., London, 61: 514, 1927). It should be mentioned that Wislocki discussed and discarded the inference of monozygosity for cases in which both embryos attach to the same placenta, as reported earlier by the same author (Anat. Rec., 52: 381–399, 1932). Unfortunately, two recent major works are somewhat misleading in regard to marmoset placentation through reference to only the earlier Wislocki paper, although the later one is cited under other topics in both (W. C. O. Hill, Primates, III: 179, Edinburgh, 1957; and Starck, *in* Primatologia, I: 826–828, Karger, Basel, 1956).

Nomenclature used above follows Hershkovitz (Proc. Biol. Soc. Wash., 71: 53–56, 1958).—George B. Rabb and James E. Rowell, *Chicago Zoological Park, Brookfield, Illinois.* *Received 2 July 1959.*

GALAGO BORN IN CAPTIVITY

No one was aware of the pending birth of a galago, *Galago crassicaudatus*, that took place in the National Zoological Park on 6 July 1959. The birth of lemuroids is not unusual in zoological collections. We were unable to determine the period of gestation, for keepers were surprised when the youngster appeared.

Galagos, known as bush babies, are found in the tropical forests of the mainland of Africa. Little has been recorded in regard to parturition in the species. The actual birth was not observed. However, several behavioristic traits are worthy of note. Soon after birth the

youngster was observed clinging to the posterior ventral surface of its mother. The greater part of the day and night the mother sat with her young in the corner of her cage. The sire, occupying the same cage with his mate and offspring, appeared unconcerned as to the activity within the enclosure. I was intrigued by the manner in which the mother transported her baby. She picked it up in her mouth and carried it, in quite the same manner that a domestic cat moves her kittens.—MALCOLM DAVIS, *National Zoological Park, Washington 9, D. C.* *Received 20 July 1959.*

PUBLICATION DATES FOR NAMES OF THE ANUBIS BABOON

The correct name for the Anubis or olive baboon is, as shown by Hill (Jour. Mamm., 40: 143, 1959), *Papio anubis*. Hill also pointed out that the first description of the animal by F. Cuvier, published June 1825, in E. Geoffroy Saint-Hilaire and F. Cuvier's *Histoire Naturelle des Mammifères*, did not include a valid scientific name. Hill erred, however, in assuming that the scientific name for the Anubis baboon, which appears in the *Table Générale et Méthodique*, or general and systematic index, to the *Histoire Naturelle des Mammifères*, was actually proposed by F. Cuvier in 1824. He also erred in assuming that a name with an earlier date than the description of the animal itself could be anything more than a *nomen nudum*. Finally, Hill is incorrect in his presumption that the 1842 date for the name *Cynocephalus anubis*, cited by Sherborn (Index Anim. 1801–1850, p. 384, 1922), was based on anything else than the original edition of the work in question.

The *Histoire Naturelle des Mammifères* is composed of 72 individually published *livraisons* which appeared at intervals from 1818 to 1842. Each part of each *livraison* bears its own date of publication at the foot of its text. The *Table* lists alphabetically and systematically all the animals described in the 72 *livraisons*. It also proposes the arrangement of the *Histoire Naturelle des Mammifères* into four volumes divided into seven separately bound books. A table of contents, or *Ordre Méthodique*, for each of the four volumes and a title page for each of the seven books are also provided. The title pages for the six books of the first three volumes are uniformly dated 1824. The seventh title page for the fourth volume (book 7) which includes the *Table*, is dated 1842.

The date on each title page cannot be regarded as valid for all parts of the book with which it is bound. Thus, volume 1 (books 1 and 2) with title pages dated 1824, contains *livraisons* 1–20 which were published from 1818 to 1820. Volume 3 (books 5 and 6) with identical title pages dated 1824, contains *livraisons* 41–60 published from 1824 to 1829. *Livraison* 50 with the Anubis baboon description dated June 1825 is in book 5 of this volume. Volume 4 (book 7), with title page dated 1842, contains *livraisons* 61–72 published from October 1829 to September 1842. The *Table* and tables of contents for all volumes are bound at the end of book 7 of the Chicago Natural History Museum set of the first, or folio, edition of the *Histoire Naturelle des Mammifères*. Other sets may have these sections inserted in the front of volume 1. An incomplete second, quarto, edition in two volumes was also published from 1826 to 1835.

As I have pointed out elsewhere (Proc. Biol. Soc. Washington, 72: 1, 1959), in a case similar to the present one, the *Table générale et Méthodique* and the tables of contents were compiled and edited by Frédéric Cuvier, *fils*, after the publication of the last *livraison* of the *Histoire Naturelle des Mammifères* and long after the death of his father, Frédéric Cuvier. Indeed, the younger Cuvier wrote (or completed ?) the last two *livraisons* numbered 71 and 72, which are dated 1839 and 1842, respectively. Obviously the *Table* where the scientific name *Cynocephalus anubis* appears could not have been published earlier than 1842. Meantime, Lesson (1827) and Fischer (1829) had already proposed valid binomials for the Anubis baboon as well as for other animals described under gallicized names in the separately published *livraisons* of the *Histoire Naturelle des Mammifères*.

The above discussion may be summarized by the following synonymy:

Papio anubis Lesson

1825 *Anubis* F. Cuvier, *livraison* 50, text and plate, in E. Geoffroy and F. Cuvier (1818–1842), Histoire Naturelle des Mammifères.
1827 *Cynocephalus anubis* Lesson, Manuel de Mammalogie, p. 45.
1829 *S[imia] anubis* Fischer, Synopsis Mammalium, p. 33.
1842 *Cynocephalus anubis* F. Cuvier *fils, Table Générale et Méthodique* in E. Geoffroy and F. Cuvier (1818–1842), Histoire Naturelle des Mammifères.

I take this opportunity to correct an error in my earlier paper on the subject (Proc. Biol. Soc. Washington, 72: 2, 1959). The final *livraison* of the *Histoire Naturelle des Mammifères*, said to be the 67th dated April 1833, is of course *livraison* 72, with its final article, *giraffe, femelle*, by F. Cuvier, *fils*, dated September 1842.—PHILIP HERSHKOVITZ, *Chicago Natural History Museum, Chicago 5, Illinois. Received 7 May 1959.*

THE FOX SQUIRREL IN NEW MEXICO

On 9 June 1958 John Poorbaugh obtained a road-killed fox squirrel, *Sciurus niger*, in Roswell, Chaves County, New Mexico. To my knowledge the fox squirrel has not previously been known to occur in New Mexico. Inquiries by Mr. Poorbaugh failed to reveal knowledge of the introduction of this species into the Roswell area. It seems likely, however, that the presence of the animals is owing to introduction by man. Mr. Poorbaugh has seen other fox squirrels in and around Roswell. The specimen referred to, a male, UNMCV 6403, is preserved in the University of New Mexico Collection of Vertebrates.—JAMES S. FINDLEY, *Dept. of Biology, Univ. of New Mexico, Albuquerque. Received 4 June 1959.*

"DAVIAN BEHAVIOR COMPLEX" IN GROUND SQUIRRELS

During the winter 1958–1959, three Richardson ground squirrels, *Citellus richardsoni*, were placed in the fur storage room of the University of Minnesota Museum of Natural History to hibernate. They were from a litter born in captivity to wild-caught parents in the spring of 1958 from Sand Lake Wildlife Refuge, Brown County, South Dakota. The fur room is maintained at a temperature of about 48° F. and relative humidity of 45 per cent. One female was awake and taken into a warm room on 11 March. Six days later a second female and a male were removed to a warm room. Each of the animals had hibernated in separate nest boxes.

The week after the male and second female were removed, they mated several times. This was accomplished with both animals lying on their sides curled in a flexed position, the male curled around the posterior end of the female much in the position used by forms that copulate in a standing position. The side position of copulation in *C. richardsoni* was observed in the 13-striped ground squirrel, *C. tridecemlineatus*, shortly thereafter.

On 26 April 1959, while driving down a dirt road in Dakota County, Minnesota, I saw two *C. tridecemlineatus* in the road. One ran into the weeds along the road; the other was dead, later found to have been shot. As I stopped the car I saw a ground squirrel run out onto the road from whence the live one had disappeared. It lay down behind the dead animal, curled in the copulatory position described above. When it left I retrieved the dead squirrel. It was a male and still retained its body heat. The dead squirrel, when picked up, was lying on its side in a position similar to that of a female ground squirrel in copulation. Undoubtedly, the flexed "female position" of the dead animal released the copulatory drive in the male which must have had a very low threshold for the act at this season of the year.—ROBERT W. DICKERMAN, *Univ. of Minnesota, Museum of Natural History, Minneapolis 14. Received 1 June 1959.*

LONGEVITY IN THE KANGAROO RAT

Apparently little is known concerning longevity of kangaroo rats. No mention of length of life is made in the study of *Dipodomys spectabilis* by Vorhies and Taylor (U. S. D. I. Bull. 1091, 1922) nor is there mention of *Dipodomys* in a recent review of longevity of captive mammals (Manville, Jour. Mamm., 38: 279–280, 1957). Hooper (Jour. Mamm., 37: 124–125, 1956) reports one *Dipodomys merriami* which lived for an estimated 5½ years. The following record of longevity of the desert kangaroo rat, *Dipodomys deserti*, in captivity is now placed on record.

A subadult *D. deserti* was collected 18 September 1952 in Calico Valley, San Bernardino County, California. It was kept for varying lengths of time at the Department of Zoology, University of California, Los Angeles and at the homes of several graduate students. It fed on seeds, toast, crumbs, etc., and for varying times came under the care of thirteen different persons. The rat died 28 February 1958, apparently of old age, living a total of 5 years and 5 months in captivity.—Bayard H. Brattstrom, *Dept. of Biology, Adelphi College, Garden City, L. I., N. Y.* *Received 9 July 1959.*

TULAREMIA IN PENNSYLVANIA BEAVER

On 15 February 1959 I examined a beaver which had been trapped and killed the night before. This beaver was infected with *Pasteurella tularensis* which causes the disease tularemia. There was an infection the size of a nickel on the center lobe of the liver. This beaver was trapped in the area of Meadville Junction in Crawford County, Pennsylvania. It was the only case of tularemia observed during the 5-week trapping season from 14 February to 21 March 1959. Ten beavers from this area were trapped and examined; this was the only one that had contracted the disease.—Fred J. Brenner, *Pennsylvania State Univ., University Park.* *Received 10 April 1959.*

HOME RANGES OF THE BOG LEMMING

Owing to the paucity of information concerning the natural history of *Synaptomys cooperi*, relatively little is known of the size of its home range. The only reference is that of Burt (Misc. Publ. Univ. Mich. Mus. Zool., 45: 1–58, 1940). He records data for one individual, a female, that had an apparent home range of about .3 acre.

During the course of a study concerned with habitat selection of small mammals, some information was obtained that adds to our knowledge of this subject. Data sufficient to yield home range sizes were obtained for seven individuals, four males and three females. Since such information is rare, it seems advisable to make it available.

The study area consisted of a grass-sedge marsh of approximately 4.4 hectares. It supported a dense stand of vegetation (approximately 325 gr/M²). The substrate was quite moist—almost completely saturated at all times. The area was live-trapped with multiple-catch traps arranged in a 12-meter (40-foot) grid. A trapping period of five days was employed each month from September 1957 through September 1958. The traps were checked twice a day, just after sunrise and again before sunset. All animals were marked by toe clipping.

The size of the apparent home range of each individual was calculated by the boundary exclusive method (Stickel, Jour. Mamm., 35: 1–15, 1954). While the determination of the apparent home range by this system is subject to error (Hayne, Jour. Mamm., 31: 26–39, 1950), it does give an estimate of its size. The data were insufficient for a more rigorous analysis.

Table 1 gives the data for each of the seven individuals, as well as for three others that were captured only twice and one that apparently had not established a definite home range. The average size of the apparent home ranges was 522 M² (.11 acre for the males and 552 M² (.14 acre) for the females.

TABLE 1.—*Apparent home ranges of Synaptomys cooperi.*

SEX	NO. CAPTURES	SIZE OF HOME RANGE, M^2	MONTH
♂	4	144	Aug.
♂	4	432	Aug.
♂	4	648	Aug.
♂	3	864	June
♀	4	504	Sept.
♀	5	504	July
♀	6	648	July
♀	2	288	Sept.
♀	2	144	Nov.
♂	2	432	Dec.
♂ *	7	1,512	April

* Had not established a definite home range.

Data concerning the apparent home ranges of *Microtus pennsylvanicus* for the same area, calculated in a similar manner, revealed sizes of 563 M^2 and 464 M^2 for the males and females, respectively. There does not appear to be a significant difference in the sizes of the apparent home ranges of the males of *S. cooperi* and *M. pennsylvanicus*. The females of *S. cooperi* may have slightly larger home ranges than those of *M. pennsylvanicus*.—LOWELL L. GETZ, *Dept. of Zoology, Univ. of Michigan, Ann Arbor.* *Received 25 May 1959.*

MUS MINUTOIDES BORN IN CAPTIVITY

On 25 December 1958 at Kabompo, Northern Rhodesia, I captured a female pigmy mouse, *Mus minutoides*, in a woodpile in the kitchen. It was kept in a cage where, on 29 December, a litter was born. Four young were observed but only one of these, a male, survived beyond the second day. The early growth stages of this individual were carefully observed. It was blind and naked at birth. On the sixth day the ears became detached and pigment in the skin was first noticed. Growth of the baby fur was complete and the incisors had erupted by the 11th day. The eyes were open by the end of the 14th day.

It is apparent from the above that the post-natal development of *M. minutoides* closely parallels that of *M. musculus*, as recorded by H. Grüneberg (GENETICS OF THE MOUSE; Martinus Nijhoff, The Hague, 1952). The chief difference was in the later appearance of the skin pigment in the specimen observed. This mouse was accidentally killed on 20 February (No. 9145 in National Museum, Bulawayo, Southern Rhodesia). Its measurements at death (aged 53 days) were as follows: Head and body, 56; tail, 41; hind foot (s. u.), 12; ear, 9.5 mm.—W. F. H. ANSELL, *Game and Fisheries Dept., Kabompo, Northern Rhodesia.* *Received 20 July 1959.*

ELECTROPHORETIC STUDIES ON BLOOD SERUM PROTEINS OF RODENTS

Investigation of the blood parasites of native rodents in the vicinity of Phoenix, Arizona, afforded an opportunity for electrophoretic studies of blood serum proteins. Eight species of seven genera and four families were observed. Electrophoretic patterns have been reported for several orders of reptiles and amphibians (Dessauer and Fox, Science, 124: 225, 1956). A marked degree of serum protein specificity has been found among closely related invertebrates (Woods *et al.*, Science, 127: 519, 1958).

Methods.—Sera, prepared from blood samples obtained by cardiac puncture, were applied in 10μl. quantities to S. & S. 2043 A-mgl. paper strips. Procedure *B* of the Spinco Model R. paper electrophoresis system was used. The buffer was Veronal of 0.075 ionic strength and of pH 8.6. A current of 3.0 microamperes (65–75 volts) was applied for 16 hours. The strips were dyed with bromphenol blue and scanned with the Spinco Analy-

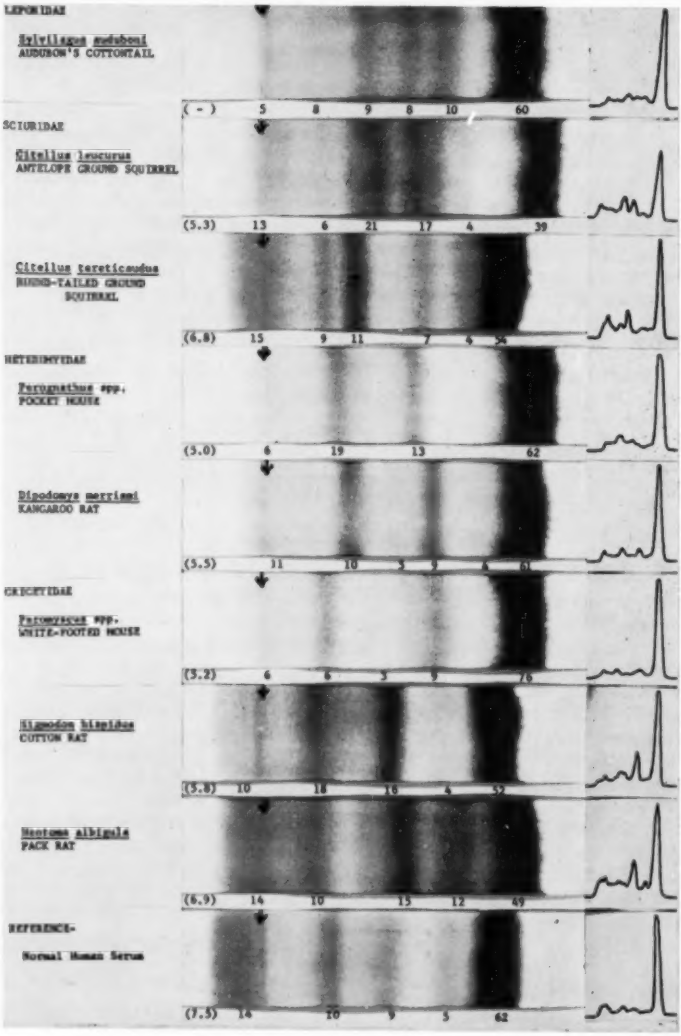

PLATE 1

Paper electrophoretic patterns and densitometer curves of the serum proteins of rodents. Arrows indicate point of sample application. The anode is to the right. The per cent of each protein fraction is indicated by a number. Total protein content (% N × 6.25) is given in parentheses.

trol, an integrating and recording densitometer. A human serum sample was run concurrently with each group of rodent sera. Total protein values were determined by a micro-Kjeldahl procedure and are uncorrected for non-protein nitrogen.

Results.—In Plate I are shown representative pherograms, densitometer curves, and analytical data for each species. Analyses of several individuals (2 to 9) of each species did not show appreciable variations.

Discussion.—It is evident from Plate I that there are generally marked differences in the serum proteins among the species. These differences are most evident among the globulins although the albumin content varies over a wide range. Where the pherograms are quite similar, the densitometer graphs may be distinctive, *e.g.*, in *Perognathus* and *Dipodomys merriami* (Sunderman and Sunderman, Amer. Jour. Clin. Path., 27: 125–158, 1957).

At the generic level, *e.g.*, the two species of *Citellus*, which are sometimes classified as subgenera, the serum proteins are very different. However, among closely related species of *Perognathus*, the pherograms and densitometer curves were indistinguishable. Subsequent studies should further elucidate the value of this method for taxonomic purposes.—A. H. Auernheimer, William Cutter and F. O. Atchley, *Communicable Disease Center, U. S. Public Health Serv., Phoenix, Arizona.* *Received 17 July 1959.*

DISTRIBUTION OF THE BOTTLE-NOSED DOLPHIN IN THE LEEWARD HAWAIIAN ISLANDS

Data on the geographical distribution of most of the smaller species of cetaceans are inadequate. The following observations of bottle-nosed dolphins, *Tursiops truncatus*, are therefore recorded. Observations were made incidental to other studies in the Leeward Chain of the Hawaiian Archipelago, an area seldom visited by zoologists. During my residence at Midway Atoll from November 1956 until July 1958, I made frequent low-altitude reconnaissance flights over all the islands and atolls in the Leward Chain, and traversed by ship at least twice the entire length of the Leeward Chain, except for that portion between Midway Atoll and Laysan Island. As far as I can determine, the literature records the occurrence of no species of dolphins in the Leeward Islands. The only other species of cetacean I observed in the area was the sperm whale, *Physeter catodon*, which was not uncommon on the open ocean.

Kure Atoll.—I made two cruises to Kure Atoll, on 5 June 1957 and 9 May 1958. On both occasions, when the vessel was within 2 km. of the reef, schools of bottle-nosed dolphins, numbering about a dozen individuals, approached and played ahead of our bow.

Midway Atoll.—Bottle-nosed dolphins were frequently observed in the waters outside, and within 1 km. of, the reef. The largest school, containing at least 50 individuals, was seen on 24 January 1957. Through a natural break on the west side of the reef, they sometimes enter the lagoon, where they remain in the deeper portion known as Welles Harbor. They were occasionally reported from the ship channel between Sand and Eastern Islands.

Pearl and Hermes Reef.—On 14 March 1958, I observed from the air a school of about 30 dolphins in the shallow water just outside the southwest portion of the reef.

Laysan Island.—On 27 May 1958, a half dozen bottle-nosed dolphins played alongside the ship for a few minutes in shoal water about 3 km. southeast of Laysan Island.

French Frigate Shoals.—On 26 May 1958, a single bottle-nosed dolphin ran ahead of our bow about 10 km. south of La Perouse Pinnacle at French Frigate Shoals.

My failure to find dolphins at Lisianski Island, Maro Reef, Necker Island, and Nihoa does not preclude the possibility of their occurrence there.

It is of interest to note that all of the above sightings were made over relatively shallow water inside, or within a kilometer of, the 18-meter (10-fathom) depth contour. However, on 5 June 1958, I saw a small school of three gray dolphins with long snouts on the open ocean about 100 km. (55 nautical miles) southeast of French Frigate Shoals. They could

have been bottle-nosed dolphins, but they swerved away from the ship, leaping high, and did not come close enough for positive identification. Elsewhere in its range, the bottle-nosed dolphin is predominantly an inshore species, its seaward distribution roughly delimited by the same contour (cf. Gunter, Fishery Bull., U. S. Fish and Wildlife Serv., 55: 548, 1954; Moore, Amer. Midland Nat., 49: 134, 1953). Its distribution is nearly world-wide, though apparently discontinuous. Are the populations local and isolated, or migratory and intermingling? The infrequency of observations far at sea would favor the former hypothesis.

No specimens have been collected in the Hawaiian Islands. All Pacific populations of *Tursiops truncatus* were referred to the race *gilli* by Tomilin (Zveri SSSR Prilezhashchikh Stran. Vol. IX Kitoobraznye. Publ. Akad. Nauk. SSSR, Moscow, 1957). However, in view of the probable isolation of the various populations, a reassessment of geographical variation in the entire species is needed. *Tursiops truncatus* is easily distinguished from *Tursiops aduncus* by the uniform coloration of its underparts, a characteristic readily observed as the animals corkscrewed under the bow.

I wish to thank the men of the U. S. Naval Station, Midway Islands, and of the U. S. Coast Guard cutters *Matagorda* and *Chautauqua*, for making these observations possible. Karl W. Kenyon, Victor B. Scheffer, and Ford Wilke offered helpful suggestions during the preparation of this note.—Dale W. Rice, *U. S. Fish and Wildlife Service, Sand Point Naval Air Station, Seattle 15, Washington.* *Received 29 May 1959.*

BLACK BEAR CARRIES CUBS FROM DEN

On 7 April 1957 a black bear (*Ursus americanus*) den was discovered by Lloyd and Keith Armstrong of Dafter, Michigan. The den was situated in a sparse hardwood stand located in the NE ¼, Sec. 34, T. 46 N, R. 4 W in Chippewa County. It consisted of a shallow unsheltered depression lined with decayed material recently clawed from a nearby stump. Apparently the den had been occupied for only several days. Presumably the occupants, an adult female with two small cubs, had been impelled to temporarily re-den by a recent snowstorm. The den site appeared to have melted free of snow prior to this fall of about 4 inches. The snow depth adjacent to the den area was approximately 24 inches.

The den occupants were first disturbed by the Armstrongs on 7 April at which time the mother left the den on their approach. On 8 April they revisited the den and the female again departed. A third visit on the morning of 9 April however, caused the mother to seize a cub by the nape of the neck and depart with it. The remaining cub was then handled by the Armstrongs, photographed and left in the den.

Later that day the junior author tracked the mother to where she had carried the first cub approximately 2¼ miles away. Here the first cub was left while she returned to the remaining cub and carried it to the same site. Several inches of freshly fallen snow, covering an accumulation of crusted snow, provided ideal tracking conditions and indicated that the mother had traveled at a rapid pace. There were no tracks of cubs and in any case it would have been impossible for these young cubs, weighing perhaps only 7 pounds, to have traveled at such a pace.

Once the initial transfer had been accomplished, the tracks indicated that the group continued in a southeasterly direction at a slow pace. Cub tracks were occasionally seen thereafter but it was impossible to determine whether both walked or whether they were intermittently or alternately carried. After approximately 2 miles the trail became obliterated by drifting snow and was lost.

To our knowledge a similar instance of a black bear transporting her young has never been reported.—Albert W. Erickson and Paul Martin, *Dept. of Fisheries and Wildlife, Michigan State Univ., East Lansing.* *Received 24 April 1959.*

SUPERNUMERARY MAMMAE IN THE BLACK BEAR

I wish to report two cases of supernumerary mammaries in the black bear (*Ursus americanus*), an occurrence not uncommon to man and anthropoid apes (Coolidge, Jour. Mamm., 24: 353–356, 1943), domestic bovids and other mammalian forms (Goertzen and Ibsen, Jour. Hered., 42: 307–311, 1951; Hyman, Comparative vertebrate anatomy; Univ. Chicago Press, p. 82, 1953), but to my knowledge not previously reported for this species. They were observed during examinations of 27 dead and 34 live-trapped female bears in Michigan. This was a minor portion of research sponsored jointly by the Department of Fisheries and Wildlife, Michigan State University, and the Game Division, Michigan Department of Conservation.

The normal nipple complement for the black bear is three pairs, one in the inguinal and two in the pectoral region. The additional pair herein reported was located on the abdomen. Both cases were in lactating individuals. In one animal taken on 9 August 1956, all eight mammae were functional and normal in appearance. In the other, taken 21 June 1957, seven mammae were normally developed and functional; one of the abdominal pair was rudimentary and apparently non-functional.

The incidence of supernumerary mammae in black bears, indicated above, apparently is low. The incidence reported for man is 1 per cent (Coolidge, *op. cit.*) and for the house mouse 9 per cent (Little and McDonald, Jour. Hered., 36: 285–288, 1945). Their occurrence is probably a throwback to an ancestral condition (Hyman, *op. cit.*).—Albert W. Erickson, *Alaska Dept. of Fish and Game, Anchorage.* *Received 4 May 1959.*

A PREHISTORIC RECORD OF THE FISHER IN GEORGIA

The Etowah Site, located 3 miles southwest of Cartersville, Bartow County, Georgia, consists of three large ceremonial or temple mounds clustered together near the north bank of the Etowah River, with smaller domiciliary mounds in the surrounding area. The main concentration of mounds and village occupation comprises approximately 40 acres and it is thought that the site was occupied from about 1,100 to 1,500 A. D. The most comprehensive early work on this site was reported by Moorehead in 1932 (Exploration of the Etowah Site in Georgia; Phillips Academy, Andover, Mass.) although, except for bone artifacts and shell, no treatment of the vertebrate remains was presented.

In 1954 the Georgia Historical Commission and the University of Georgia, Department of Anthropology and Archaeology, began a detailed exploration of Mounds B and C, the smaller of the three temple mounds. Through the cooperation of Lewis H. Larson, Jr., and A. R. Kelly, most of the faunal remains recovered by them were made available to the author for study. A large variety of species were identified from the sample. Bones of the white-tailed deer, black bear, beaver, squirrel (*Sciurus*), opossum, turkey, passenger pigeon, turtles (*Terrapene* and *Pseudemys*), and fresh-water drum were the most numerous of their groups.

The most noteworthy record is that of a right mandible of an adult fisher, *Martes pennanti*, found in a refuse pit beneath Mound B. The ascending ramus had been cut off immediately posterior to the second molar and both lateral surfaces of the jaw bore faint scratch marks; although only the canine tooth, second and third premolars, and the first molar remained, originally this artifact apparently contained a full complement of teeth. Miller and Kellogg (U. S. Nat. Mus., Bull. 205: 728; 1955) state that the fisher ranged "formerly south in Allegheny Mountains to North Carolina." There are a few archeo-zoological records of this mustelid which have helped to extend or establish definitely the known range (Parmalee: Jour. Mamm., 39: 153, 1958; Guilday: *ibid*, 37: 287, 1956). Although this mandible had been worked by the Indian and might conceivably represent a trade item, there are records of worked fisher jaws and skulls (Webb: Indian Knoll; Univ. Ky., Rept. in Anthropol. 4, 1946) in regions where the species was thought definitely to occur.

Bartow County is situated in northwestern Georgia and the local Etowah Site region lies in the Great Valley between two southern range extensions of the Appalachian Mountains.

The areas east of the Cartersville Fault are still partially timbered; the once thickly wooded flood plain of the Etowah River and the closely situated mountain ranges of mixed mesophytic forest could have provided suitable habitat for the fisher. Therefore, it is reasonable to assume that the animal was killed in close proximity to the site. This record is of interest since the fisher has apparently not been previously reported from Georgia and because it represents a more southerly range extension of *M. pennanti* in the southeastern United States. —Paul W. Parmalee, *Illinois State Museum, Springfield. Received 6 April 1959.*

VITAMINS A AND E IN DEER BLOOD

Some exploratory analyses of blood samples of deer, *Odocoileus virginianus*, were conducted in Alabama in 1955 and 1956. The preliminary results are reported at this time as there is little likelihood the work will be continued now that both authors have terminated their connections with Alabama Polytechnic Institute and have moved from that state.

Blood samples were obtained from 19 deer (Table 1). All were checked for carotenoids, 12 for vitamin A, and 13 for vitamin E by standard methods. Since no carotenoids (precursors to vitamin A) were found in the blood, it appears that the deer resembles the goat, pig and rabbit in which species vitamin A is formed in the wall of the gut. The amounts of vitamin A ranged between 13.4 and 44.0 μg./100 ml. blood plasma, with 11 of the 12 samples having values within the 15–40 μg. range, which may represent the so-called normal range for some species. All of the wild deer sampled for vitamin E were found with quantities of vitamin E that were well below the 400–1400 μg. level that is thought to represent "so-called" normal level for some other species. If requirements for vitamin E of deer are such that the observed values represent inadequate intake of this factor, then the wild deer in the Salt Springs Sanctuary in Alabama here sampled could possibly contract white muscle disease under certain conditions. This would be especially true if their food supply should change to include increased amounts of foods containing high levels of stress factors, such as highly unsaturated fats, or some of the cresol compounds present in acorns and other plant products, or other oxidative factors known to have anti-vitamin E potency.

Table 1.—*Vitamins A and E content of 19 blood samples from white-tailed deer in Alabama*

NO., SEX	AGE	DATE	CAROTENOIDS	VITAMIN A	VITAMIN E	COMMENTS
			micrograms per 100 ml. blood plasma			
3022—	2 mo.	11 Oct. '55	0	27.5	980	Captive
3023 ♂	2 "	"	0	21.5	1050	"
3024—	2 "	"	0	13.4	546	"
3025—	2 "	"	0	18.7	700	"
553 ♂	adult	27 Jan. '56	0		294	Wild
554 ♀		"	0		290	"
556 ♀		"	0		137	"
557 ♀		"	0		423	"
558 ♀		"	0		330	"
559 ♂	adult	"	0		236	"
560 ♀		"	0	44.0		"
561 ♂	6 mo.	"	0	15.7		
562 ♀						
563 ♀ *	adult	"	0	38.2		"
564 ♂	"	"	0	27.7		"
565 ♀ †	"	"	0	33.9		"
3023 ♂	7 mo.	19 Mar. '56	0	27.9	160	Captive
3026 ♀	2½ yr.	"	0	25.0	122	"
2224 ♂	5 "	11 Sept. '56	0	36.6	241	Had brain abscess

* Had lactated. † Blind in right eye.

Two cases of white muscle disease in deer were diagnosed clinically and histologically at the School of Veterinary Medicine of the Alabama Polytechnic Institute. One case involved a wild buck from southwestern Alabama; the second involved a captive fawn kept for experimental purposes at the Wildlife Research Unit.

This research was conducted while the authors were at Alabama Polytechnic Institute, the senior author as Leader of the Alabama Cooperative Wildlife Research Unit. The Unit is sponsored jointly by the Alabama Department of Conservation, Alabama Polytechnic Institute Agricultural Experiment Station, the Bureau of Sport Fisheries and Wildlife, and the Wildlife Management Institute. The junior author formerly served as animal nutritionist in the Agricultural Experiment Station at Alabama Polytechnic Institute.—ARNOLD O. HAUGEN, *Iowa Cooperative Wildlife Research Unit, Iowa State College, Ames,* AND EDWIN L. HOVE, *National Institutes of Health, Bethesda, Maryland.* *Received 6 May 1959.*

A TWO-HEADED WHITE-TAILED DEER FETUS

Because of the scarcity of published information on anomalies in deer, the following account of a two-headed fetus found in a white-tailed deer, *Odocoileus virginianus borealis*, is given.

Dogs chased a doe injured by shot wounds onto the ice on Higgins Lake, Roscommon County, Michigan, on 25 February 1957. Fishermen reported the incident and a Conservation Department employee humanely dispatched the deer. The fetus was discovered by

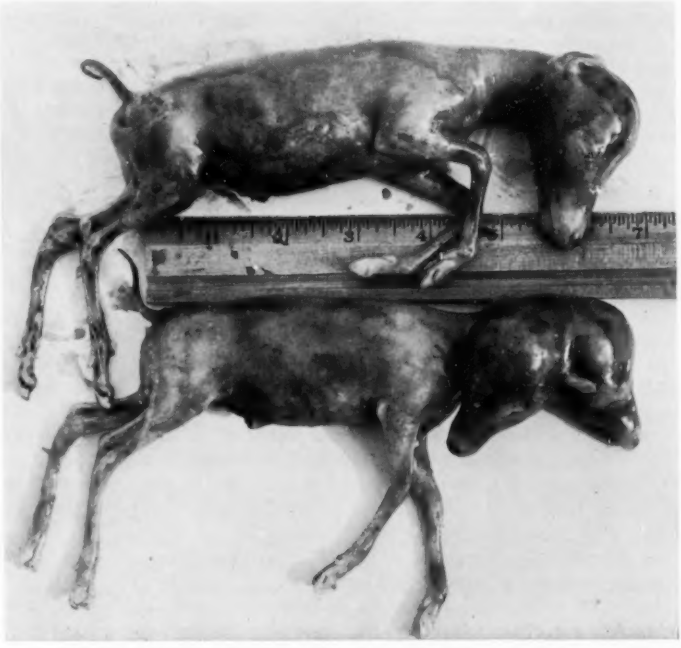

PLATE I

Twin fetuses from white-tailed deer. Normal male above, two-headed female below.

biologists of the Houghton Lake Wildlife Experiment Station, Houghton Lake Heights, who autopsied the doe.

The doe was determined from the dentition to be about 6½ years old. She was in poor physical condition attributable to the general scarcity of winter deer food in the area. She was carrying two fetuses (Plate I), one a normal male weighing 192 grams, the other a two-headed female weighing 183 grams. The anomalous female was 177 mm. long from crown to rump when measured as shown lying on its side. The heads were joined in the occipital region with the noses directed laterally. There was an ear on the lateral (free) surface of each head and a single ear in the "V" formed by the union of the heads. Posteriorly, the body was that of a normal fetus with a single neck, trunk, and paired limbs.

This is the only instance of dicephalism in deer we have observed in over 2,300 fetuses examined over the past eight years. The preserved specimen is in the possession of the Game Division, Department of Conservation, Lansing, Michigan.—L. D. FAY, *Michigan Dept. of Conservation, Lansing. Received 26 June 1959.*

ANTLER ANOMALIES

Robinette and Jones (Jour. Mamm., 40: 96–108, 1959) refer to a correlation between unilateral antler abnormalities in deer and wounds on the opposite side of the body. There is a correlation, that is to say, between abnormal right antlers and wounds on the left side of the body, and vice versa.

The authors observe that there appears to be no obvious physiological reason for this, and indeed the idea of some kind of physiological chiasmus is not easy to conceive.

May not the explanation be a simple mechanical one? A deer is wounded on its left side. The wound takes some time to heal. Meanwhile the deer wanders about, every now and then turning its head to lick the wound. Each time it does this the left antler is relatively protected, but the right one risks being swung into, or run into, a tree or some other obstruction. And an antler in velvet could easily be damaged.—T. C. S. MORRISON-SCOTT, *Science Museum, London, S. W. 7, England. Received 13 July 1959.*

THE MANATEE IN THE LESSER ANTILLES

Although the Antillean manatee, *Trichechus manatus manatus*, was among the first mammals to be observed by European man in the western hemisphere (Baughman, 1946: 234), very few specimens are to be found in museums and apparently none of these were obtained in the Lesser Antilles. In fact, recent authors (Allen, 1942: 539; followed by Westermann, 1953: 30) have asserted that "among the Lesser Antilles it seems not to occur at present and perhaps does not find suitable conditions there."

Several lines of evidence indicate that the manatee occurred in the Lesser Antilles well into modern time if not to the present. Gazetteer No. 34 of the U. S. Board on Geographic Names lists a town, a river, and a bay of Lamentin on the northeastern coast of the Basse Terre of Guadeloupe, and a town and a cove of Lamentin on the northeastern shore of Fort de France Bay, Martinique. Among a large collection of bones from Antillean archeological sites submitted to me for identification by Irving Rouse of Yale University, is a manatee rib collected by Marshall McKusick at a Choc Indian site 4 miles north of Castries on the northwestern coast of St. Lucia.

It is possible (if implausible) to attribute the geographic names alluding to the manatee to whimsy on the part of the settlers, and the single rib to postmortem transport on the part of the Indians, but there are at least two reliable historic accounts of the manatee in the Lesser Antilles. The earliest of these accounts is than of Olfert Dapper (1673: 219) who, in his description of Marie Galante, states as follows:

In der See wird der so genennete Fisch Lamantin heuffig gefangen/und gleich als Abberdan zum vorrahte bewahret. Dieser Fisch wächset achtzehen Füsse lang/und sieben dicke. Der Kopf gleichet fast einem Kuhkopfe. Er hat kleine Augen/eine dicke braune Haut/welche an etlichen Örtern geruntzelt und rauch ist/und zween kleine Füsse an stat der Flossfedern. Er lebet bei grühnem Kraude/das auf den Sandbäncken und Steinfelsen wächset. Das Weiblein wirft allemahl zwen Jungen/welche an eben so viel Zitzen saugen. Das Fleisch/welches gesund und wohlschmäckende ist/siehet man mit Fette durchwachsen. Dieses Fet/wan es geschmoltzen ist/schimmelt /noch verdirbet nicht. Man fänget sie mehr im Munde der süssen Flüsse/als in der vollen See.

The second account is that of Père Labat (1724, Tome II: 200–207), who describes at length a manatee caught at Cul-de-Sac Robert on the central eastern coast of Martinique. The accuracy of the extended descriptions of the manatee given by Dapper and Labat leaves no doubt as to the authenticity of their reports. Brandt (1868: 253) was aware of Dapper's record and included Marie Galante in the range of the manatee, as did Grevé (1897: 55) and Hartlaub (1886: 101), but the record has apparently eluded twentieth century authors. Both Grevé and Hartlaub included Martinique in the range of the manatee without citing their authority but, although Allen, Baughman, and Westermann cite Labat's work, they do not mention his account of the manatee in Martinique. It is not impossible that the manatee occurs in the Lesser Antilles today, having perhaps escaped scientific notice by virtue of its retiring nature and the inadequacy of zoological investigation in this area.—Clayton E. Ray, *Museum of Comparative Zoology, Cambridge 38, Massachusetts. Received 6 July 1959.*

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NOTES ON OAXACAN MAMMALS

Southeastern parts of the Mexican states of Oaxaca and Veracruz in the Isthmus of Tehuantepec are now more accessible for biological investigation because of newly constructed, all-weather roads. As a result, the authors have had the opportunity to visit formerly remote places in the Isthmus in 1953 and 1955 as members of field parties from the Museum of Natural History at the University of Kansas and again in 1958 from the Museum at Michigan State University. The latter trip was provided for, in part, by the Michigan State University Development Fund.

Camps were made each of the three years in July and August at a place 1 mile south of the Oaxacan village of Tollosa (locally called Tolosita). Tollosa, at an elevation of approximately 300 feet above sea level, is on the south bank of the Río Jumuapán (called Río

Tolosita by local residents) and may be reached by either the new highway crossing the Isthmus from Juchitán to Acayucán or by railroad. The surrounding country is generally hilly with many level places presently or formerly in cultivation. Some areas show the effects of periodic fires. Humid, lowland forests occur adjacent to the highway, but the largest trees usually grow on or near low, rocky hills.

Extensive stands of large trees along the north-south roadway occur in Oaxaca in the vicinity of Tollosa and northward toward and into the state of Veracruz. Forested cover to the southward is generally lower and gradually gives way to the more arid-tropical habitats characteristic of the Pacific side of the Isthmus. Observations also indicate that the fauna in the vicinity of Tollosa resembles more closely that found in the humid, lowland forests of Veracruz than that found to the southward in Oaxaca.

Campsites were located east of the highway on a truck road leading to a low, densely forested hill from which rock for road-fill frequently was quarried. In appearance the area had not changed appreciably from 1953 to 1958. In 1958, however, conspicuous species of birds and mammals seemed much less abundant than in either 1953 or 1955. Increased travel and related disturbance had, according to local residents, caused the decrease, although we suspect that unregulated hunting by natives also was a major factor. Spider monkeys (*Ateles geoffroyi vellerosus* Gray) were collected in 1953 and 1955 in trees on the low hill east of camp but in 1958 were not observed; local residents also reported fewer records of this species in the vicinity in the latter year. Tracks and other sign of white-tailed deer (*Odocoileus virginianus*), brocket (*Mazama americana*) and peccary (*Tayassu tajacu*) were less common in 1958, although one brocket was seen at dusk on 31 July ½ mile south of camp. In each of the three years, hunters at Tollosa reported that tapir (*Tapirus bairdii*), white-lipped peccary (*Tayassu pecari*) and howler monkey (*Alouatta villosa*) occurred in mountainous districts one or more days by foot or in canoe from the village. On 1 August one of us (Greer) and Victor Hogg heard spider monkeys 6 miles west of camp and received reports of the presence of tapir, peccary, deer and jaguar (*Felis onca*). This place was reached by canoe traveling upstream on the Río Jumuapán.

In 1958, it was evident that large birds including the mealy parrot (*Amazona farinosa*), keel-billed toucan (*Rhamphastos sulfuratus*) and crested guan (*Penelope purpurascens*) were less common than in previous years and that the currasow (*Crax rubra*) rarely was found anywhere in close proximity to the highway. The construction of all-weather roads is certain to be a boon to local transportation and commercial development but also allows for increased hunting and other disturbances with the resultant reduction of conspicuous and edible kinds of tropical wildlife.

The following comments concern mammals observed or collected in the vicinity of Tollosa in 1958 (28 July to 5 August). All specimens obtained are preserved in collections of the Museum at Michigan State University. We are indebted to the other members of the field party, Victor Hogg, Max Hensley, Russell Jameson, Clifford Thomas and Robert Webb, for their cooperation and assistance in this study.

Balantiopteryx io Thomas. Thomas' sac-winged bat.—Thirteen examples of this bat, not previously reported from Oaxaca, were obtained in a cave ½ mile south of camp. This cave, in a low limestone hill, opened after a narrow passageway about 25 feet in length into two connecting chambers. Each chamber was about 30 feet in diameter and 20 feet high and contained a few small pools of water, stalactites and stalagmites. The room nearest to the entrance was dimly lighted; the other room was dark. Approximately 300 bats of this species were found clinging in a random fashion to the ceiling of these chambers. *Desmodus* was the only other bat found in the cave. Of specimens of *Balantiopteryx* obtained on 30 July, three females were lactating and weighed 5.5 to 6.0 grams.

Carollia perspicillata azteca Saussure. Seba's short-tailed bat.—Two males were trapped at night in a mist net stretched across a narrow forested stream. Weights were 19.5 and 20.0 grams, respectively.

Desmodus rotundus murinus Wagner. Vampire bat.—Eight specimens, including

young, were captured in a cave from which *Balantiopteryx* also was obtained. A colony of approximately 100 vampires was roosting in a cavity (4 feet high and 2½ feet across) in the ceiling of the dark inner chamber. Guano to a depth of 4 inches was deposited on a large boulder below this roost. The young vampires, examined by graduate student Aretha Collins, possessed two deciduous incisors and a deciduous canine on each side of the upper jaw; no other deciduous teeth were present. In the upper jaw, at least, permanent incisors appear medially and anteriorly to deciduous incisors while permanent canines erupt only slightly anteriorly and medially to the deciduous canines. The permanent canines seem to become functional earlier than do the permanent incisors in the upper jaws.

Eptesicus brasiliensis propinquus (Peters). Brazilian brown bat.—One lactating female was caught in a mist net suspended over a forested stream. This bat weighed 10.6 grams and had the following external measurements: Total length, 101; length of tail vertebrae, 40; length of hind foot, 9; height of ear from notch, 14 mm.

Dasypus novemcinctus mexicanus Peters. Nine-banded armadillo.—This mammal is common in second-growth vegetation. Burrows and other sign were observed near camp. The skulls of three animals were obtained from local hunters who captured them using dogs for trailing.

Peromyscus mexicanus mexicanus (Saussure). Mexican deer mouse.—Five specimens were captured in moist, shaded jungle in rocky locations. Sherman live-traps baited with rolled oats proved more effective in catching these mice than did wooden-base snap-traps. One female taken on 2 August was lactating.

Sigmodon hispidus saturatus Bailey. Hispid cotton rat.—Four richly colored specimens, taken in live-traps in grassy areas, seem best referred to *saturatus* rather than to *S. h. tonalensis* Bailey, found to the southward. Sign indicated that this cotton rat was abundant. One female, taken on 31 July, contained five embryos.

Dasyprocta mexicana Saussure. Mexican agouti.—The skull of an agouti was brought in by native hunters who use dogs to track these edible rodents. At dawn on 2 August, another was seen running rapidly through undercover at the edge of a jungle clearing toward a rocky area. Local residents told us that the paca (*Agouti paca*) occurs in the vicinity of Tollosa and also is prized for its meat.

Nasua narica narica (Linnaeus). Coati.—This animal is fairly common in the area. The skull of a female was received from a local hunter.

Potos flavus aztecus Thomas. Kinkajou.—The weird cry of this nocturnal mammal was heard frequently in early evening. The kinkajou was attracted to the fruits in tall forest trees; on one occasion three individuals were observed in a tree. This species is hunted less by local people than are coati and agouti. One adult male was preserved.—Rollin H. Baker and J. Keever Greer, *Michigan State Univ., East Lansing.* *Received 24 April 1959.*

RECENT CHANGES IN THE MAMMAL FAUNA OF MOUNT DESERT ISLAND, MAINE

The mammals of Mount Desert Island, an area of 100 square miles just barely off the mainland in the Gulf of Maine, were reported (Jour. Mamm., 23: 391–398, 1942) as known twenty years ago. The list included 44 species. Certainly additions are still to be made to the four species of bats then known. Aside from these, there have been other changes, at least some of them possibly influenced by the severe fire of 1947. This fire, following a long period of hot, dry weather and fanned by a strong northwest wind, raged uncontrolled from 21–25 October and threatened to engulf most of that half of the island east of Somes Sound. Not until 7 November was it declared officially out, and in places it continued to smolder 4 feet underground for some time longer. In all, 17,000 acres were burned, about half of them within the confines of Acadia National Park. Damage was extensive and

general except for isolated pockets as at Great Head, Otter Point, Jordan Pond, Northeast Harbor, Sieur de Monts Spring and elsewhere. The fire and the subsequent recovery of the forest are described by R. G. Smith (Amer. Forests, 66 (3): 28–30, 53–54, 1960). I first revisited the island on 12–17 August 1959. Revegetation was well advanced on the burned areas, and mammals and birds were re-established in most suitable sites. To Paul G. Favour, jr., Park Naturalist, I am grateful for much of the information listed beyond.

Lasiurus borealis.—Two specimens of the red bat were previously listed. John A. King reported (27 October 1959) that a third, found on the island, was recently presented to him.

Marmota monax.—Woodchucks have increased slowly; there are now about five authenticated records on the island, in the vicinity of Cadillac Mountain.

Tamias striatus.—The chipmunk continues abundant and is the most conspicuous small mammal on the island.

Sciurus carolinensis.—The fire of 1947 took a heavy toll of the newly established gray squirrels, if not eliminating them altogether from the island's fauna. None have been seen or reported recently.

Castor canadensis.—Beavers are plentiful on the island, to the point where recent cuttings or active colonies are present on nearly every stream and pond with suitable food and cover.

Synaptomys cooperi.—John A. King informs me that the bog lemming, not previously recorded from the island, was taken on 10 August 1959 by Joseph Felsenstein in a damp spruce grove opposite the Hamilton Station of the Roscoe B. Jackson Memorial Laboratory, at Hull's Cove. The specimen, a lactating female, is now in the U. S. National Museum (No. 288024).

Erethizon dorsatum.—The porcupine, formerly "extremely rare or absent on the island," has become established and increased in numbers. One was noted killed on the highway near the bridge to Trenton.

Vulpes fulva.—The red fox has apparently increased in numbers. An adult and kit have been seen repeatedly near Great Head, possibly attracted there by abundant small birds and mammals in the wake of the fire.

Procyon lotor.—Raccoons have increased and are commonly seen at night along roads at the lower levels.

Mustela vison.—Minks are still present on the island, but have decreased noticeably in numbers. One was reported seen along the seashore at Seawall, but seldom are they encountered.

Mephitis mephitis.—Striped skunks continue abundant on the island; many are killed by automobiles.

Lynx rufus.—The bobcat has recently been reported, and is probably established, on the island, although in small numbers.

Phoca vitulina.—Harbor seals have continued to decline in the waters about Mount Desert Island, but a few are still seen in remote areas, especially in early spring.

Odocoileus virginianus.—White-tailed deer, long a problem on the island, have continued to increase in most areas. There still is no legal hunting on the island. Paul G. Favour, jr., estimates their present population at from 1,000 to 1,500. A small herd has recently become established on Baker Island, over 3 miles to the south of Mount Desert Island.

Alces alces.—In the past five years moose have been regular visitors to the island each fall, as many as five appearing at one time. One even swam the 1½ miles southward to Little Cranberry Island, but remained there only briefly.—RICHARD H. MANVILLE, *U. S. Fish and Wildlife Service, Washington 25, D. C.* *Received 25 August 1959.*

REVIEWS

Haltenorth, Theodor. KLASSIFICATION DER SÄUGETIERE I (1 und 2). In Handbuch der Zoologie, Band VIII: Mammalia. Walter de Gruyter & Co., Berlin. 40 pp. 1958.

This issue represents the first of a series to be written by the same author, which will constitute Part I (Classification of Mammals) in the 8th volume of the *Handbuch der Zoologie*. This first issue covers the classification of Monotremata and Marsupialia.

Compact and pertinent morphological and anatomical descriptions are provided for both orders. General information on their development, life history and geographic distribution is also given. Additional data on these topics are found in the descriptions of families, genera and species. A complete list of known subspecies is supplied, together with indications of the geographic regions where each of them is found. One feature, peculiar to this publication, has to do with the fact that for the first time each species and subspecies has been provided with a common German name, in addition to the technical name. English common names are also given for the genera. As the author states in his foreword, the latter were taken from E. P. Walker's *Genera of Recent Mammals of the World*, which is now in preparation.

Eight plates of excellent black-and-white drawings by H. Diller portray representatives of a number of genera.

On the whole, this is a carefully prepared and well-printed section, which gives an up-to-date review of the classification of the orders under consideration. It is quite up to the high standards of the *Handbuch der Zoologie*, and the following sections will be anticipated with extreme interest.—W. PRYCHODKO.

Slevin, Joseph Richard. THE GALÁPAGOS ISLANDS: A HISTORY OF THEIR EXPLORATION. Occas. Paper No. 25, California Academy of Sciences, San Francisco. Pp. x + 150, 31 figs. 22 December 1959. Price, $3.75.

Here is a wealth of delightful reading for those who like their natural history heavily spiced with documentary history. This volcanic archipelago of some 15 islands and numerous islets and rocks, astride the equator and 500 miles off the coast of Ecuador, was "discovered" in 1535 by Fray Tomás de Berlanga, Fourth Bishop of Panamá—legends attest its earlier discovery by the Inca king, Tupac Yupanqui. Biologists know it as the home of gigantic land tortoises, marine iguanas, an abundance of somber birds (including an intriguing variety of small finches), and as the area visited from 15 September to 20 October 1835 by H. M. S. *Beagle*, with Charles Darwin as naturalist. Expeditions had visited the islands before this, and many have since. Here are recorded details of all these events—extracts from ships' logs, pictures and plans of the *Beagle*, accounts of shipwrecks, bits of early journals, reproductions of old maps, tales of some of the men and ships associated with the Galápagos, and much else. This is not intended as a biological treatise, but an extensive bibliography provides leads to the vast literature on the flora and fauna of these islands. They are not memorable for their mammals. Apparently the only indigenous forms were a bat (*Lasiurus*) and a few species of rodents (*Oryzomys*), some now probably extinct. Introduced forms now established in the feral state include cats, dogs, rats, cattle, burros, pigs and goats. Vessels engaged in the fur trade during the 1800's were attracted by the Galápagos fur seal, now extremely rare and apparently confined to Tower Island. More particularly, between 1790 and 1860, these waters were favored by the whaling fleets, comprising a tremendous drain on the tortoise population and furnishing much of the lore of the "Enchanted Isles" so well recorded here.—RICHARD H. MANVILLE.

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Books Received

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Davis, W. B. *The mammals of Texas.* Texas Game & Fish Comm., Austin. 1960. 252 pp. 50 cents.

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Fisher, R. A. *The genetical theory of natural selection.* 2d ed. Dover, N.Y. 1958. 291 pp. $1.85.

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Stodola, F. H. *Chemical transformations by microorganisms.* Wiley, N.Y. 1958. 134 pp. $4.25.

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Walker, W. F., Jr. *Vertebrate dissection.* 2d ed. Saunders, Phila. 1960. 340 pp. $4.25.

COMMENTS AND NEWS

NEW AUSTRALIAN MAMMAL SOCIETY

Members may not all be aware of the recent organization of a sister society "down under." In August 1958, at the Congress of the Australian and New Zealand Association for the Advancement of Science, held at Adelaide, the "Australian Mammal Society" was organized, a set of rules was drawn up, Shelley Barker was elected Secretary-Treasurer, and invitations were drafted to interested parties, 24 of whom subsequently became members. The Society's Inaugural Meeting was held at the University of Western Australia, Perth, on 21 August 1959; the second annual meeting was held at the University of Sydney on 24 May 1960. Bulletin No. 1 was issued in February 1960, and the eventual publication of a journal is contemplated.

Membership is open to all interested parties, upon nomination and seconding by a member of the Society. Annual dues are one pound (about $2.25). Anyone interested should write to Dr. A. Gordon Lyne, Secretary-Treasurer, C.S.I.R.O., Ian Clunies Ross Animal Research Laboratory, P.O. Box 144, Parramatta, New South Wales, Australia. American members of the Australian Mammal Society, who would welcome the opportunity of proposing interested persons for membership, include B. Elizabeth Horner, R. A. Stirton, J. Mary Taylor and Hobart M. Van Deusen.

GRIFFIN HONORED

Recently elected to membership in the National Academy of Sciences, by reason of his distinguished and continued achievements in original research, was Dr. Donald R. Griffin, a member of this Society since 1929. He is best known for his studies on migration of bats, sensory physiology, navigation and echolocation in bats and birds. He formerly taught physiology and zoology at Cornell University, has been professor of zoology at Harvard University since 1953.

PHOTOGRAPHERS' CONVENTION

The 30th Annual Meeting of the International Biological Photographic Association, sponsored by its Intermountain Chapter, will be held at Salt Lake City, Utah, 23–26 August 1960. All persons interested are invited to attend. Futher information may be obtained from Howard E. Tribe, Division of Medical Illustration, University of Utah, Salt Lake City 12, Utah.

NSF GRANTS

The Division of Biological and Medical Sciences of the National Science Foundation announces that the next closing date for receipt of basic research proposals in the Life Sciences is 15 September 1960. Proposals received prior to that date will be reviewed at the fall meetings of the Foundation's advisory panels and disposition will be made approximately four months following the closing date. Proposals received after the 15 September 1960 closing date will be reviewed following the spring closing date of 15 January 1961. Inquiries should be addressed to the National Science Foundation, Washington 25, D. C.

AIBS TRANSLATION PROGRAM

The American Institute of Biological Sciences is currently translating and publishing seven Russian research journals in biology. These journals are translated with support from the National Science Foundation, which is eager that such information be more widely distributed to biologists throughout the world. It is hoped that this material will aid biologists in research, prevent duplication of work, give some idea of the work being done by Soviet scientists in the field of biology, and also bring about a better international understanding among scientists.

Because of the support of the National Science Foundation, the AIBS can offer these translations at a fraction of their publication cost, with even further price reduction to AIBS members and to academic and non-profit libraries. This reduction, the AIBS feels, places the translation within the reach of all biologists.

The journals currently being translated are: Doklady: Sections on Biological Sciences, Botanical Sciences and Biochemistry; Plant Physiology; Microbiology; Soviet Soil Science; and Entomological Review. In addition to this program, the AIBS has instituted a separate program of translation and publication of selected Russian Monographs in biology. Six (none on mammals) are already available and others are under consideration.

Additional information pertaining to this program may be obtained by writing to the American Institute of Biological Sciences, 2000 P Street NW, Washington 6, D. C.

RUSSIAN TRANSLATION

The Israel Program for Scientific Translations is publishing, for the National Science Foundation and the U. S. Department of Health, Education and Welfare, translations of scientific Russian literature. Now available for $3.25 is "Glands of internal secretion in the embryonic development of birds and mammals," by M. S. Mitskevich (304 pp., 1957). Copies may be ordered from the Office of Technical Services, Washington 25, D. C.

DEATH REPORTED

Paul Bartsch, 24 April 1960

PERSONAL NOTICES

This space is available to members of the Society for brief notices of interest to mammalogists. Copy should be sent to the Editor by the 10th of the month preceding publication. Rates for single insertion are 25 cents per line or portion thereof. Notices will be continued in each issue unless cancellation is received a month before publication or unless specified in original order. Bills will be rendered by the Secretary-Treasurer following publication.

WANTED—The following numbers of the *Journal of Mammalogy* are needed to complete my set: Vol. 1, Nos. 1, 2, 3; Vol. 2, Nos. 1, 2, 3; Vol. 3, complete; Vol. 5, Nos. 1, 2, 3; Vol. 6, Nos. 1, 3; Vol. 27, No. 1; Vol. 29, No. 1. Anyone having extra copies of these numbers please contact Dr. B. B. Butterworth, Biology Dept., Univ. of Southern California, Los Angeles 7.

FOR SALE—*Japanese "Mist" Bat Nets.* Send for price list. W. B. Davis, 254 F.E., College Station, Texas.

FOR SALE—Live desert rodents. Send for information and price list. Keith E. Justice, 44 W. Rillito St., Tucson, Arizona.

KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

URGENTLY NEEDED—*Serum of foreign pinnipeds* for a comparative study involving electrophoretic and immunologic work on pinnipeds of the world. Directions for preservation and shipping sent on request; we assume shipping costs. Murray L. Johnson, Museum of Natural History, University of Puget Sound, Tacoma 6, Washington, U. S. A.

FOR *Sherman Live Traps* write H. B. Sherman, P.O. Box 683, De Land, Florida.

FOR SALE—Bailey's *The Mammals of Virginia,* 432 pp., 99 illus., 1946. Originally $5.00. Few copies left, $2.50 each. John W. Bailey, 27 Willway Rd., Richmond 26, Va.

ALL-PETS MAGAZINE is written for hobbyists, breeders, fanciers and people engaged in pets for profit; covers all unusual livestock kept as pets, plus aquaria, cage and aviary birds, cats and dogs; subscription $3.50 per year. Manuscripts solicited from ASM members. Established 25 years, circulation world-wide, 80 pages and up monthly. We also publish books on pet livestock; some 80 titles now. National distributors of some 350 books on pets. Write for free book circular to Frank Dittrich, 139 Darling Place, Fond du Lac, Wisconsin.

FOR SALE—*Transactions San Diego Society of Natural History,* complete set, Vols. 1–11 with Vol. 12 in progress, newly bound in blue buckram, $125. L. M. Huey, Natural History Museum, Balboa Park, San Diego 1, Calif.

FOR SALE—Write to Lee R. Dice, 1120 Brooks St., Ann Arbor, Mich., for list of books offered from his private library.

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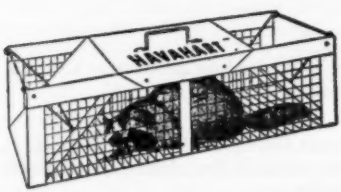

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